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RESEARCH STUDY OF HIGHWAY SNOWDRIFTING

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Disclaimer

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Un sommaire en français de ce rapport est inclus avant la table des matières.

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The associated report, "Guidelines for Controlling Snowdrifting on Canadian Highways", TP 9937, provides information on various methods of reducing snowdrifting.

16. Abstract

This study researched snowdrifting problems on Canadian highways and developed typical solutions to these problems.

The objectives of this study were to improve existing and develop new methods to control drifting snow across highways in order to improve highway safety and reduce maintenance costs associated with snow removal.

In order to meet these objectives, a literature search, a survey of highway departments and a number of highway site visits were conducted over a three year period. The literature search and survey assisted in determining the direction of the study and the selection of the study sites. Initially, over 35 sites were visited in Ontario, Quebec, the Yukon and Northwest Territories to identify typical problem conditions.

The problem conditions observed during the 1986-87 winter were reviewed along with local meteorological data to develop solutions during the summer of 1987. These solutions were installed at each site prior to the winters of 1987-88 and 1988-89. The data collected were analyzed to produce guidelines to be used by roads department staff to reduce snowdrifting on highways.

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Le rapport TP 9937 "Propositions pour le contrôle de l'enneigement des autoroutes canadiennes" fournit des renseignements sur différentes méthodes utilisées pour réduire les accumulations de neige sur les autoroutes canadiennes.

16. Résumé

Cette étude traite des problèmes posés par l'accumulation de neige sur les autoroutes canadiennes et propose des solutions applicables à ces situations.

Les buts poursuivis consistent à améliorer les méthodes actuelles de contrôle d'accumulation de la neige et en développer de nouvelles dans l'intention de rendre les autoroutes plus sécuritaires et de réduire les coûts d'entretien associés au déblaiement de la neige.

Des recherches bibliographiques, des études du département des autoroutes et des visites de sites ont permis d'accomplir ces objectifs. La détermination des lignes conductrices et le choix des sites étudiés ont été décidés suite aux recherches bibliographiques et aux études menées. Au départ, 35 sites situés au Québec, en Ontario, au Yukon et dans les Territoires du Nord-Ouest ont été visités afin d'identifier des cas de problème typique.

Les conditions associées au problème ont été étudiées en parallèle avec les données météorologiques locales afin de développer des solutions appropriées durant l'été 1987. Celles-ci ont été installées sur chacun des sites avant les hivers de 1987-88 et de 1988-89. Les données récoltées ont été analysées et ont permis de produire un rapport complémentaire à ce guide afin d'être utilisé par les services de voirie dans le but de réduire l'accumulation de neige sur les autoroutes.

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8) City of Sault Ste. Marie, Ontario
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11) County of Dufferin, Orangeville, Ontario
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13) Department of Transportation, New Brunswick
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SUMMARY

This report has been prepared by Rowan Williams Davies & Irwin Inc. (RWDI) Guelph, Ontario as a co-operative venture funded by four federal departments and two territorial governments (Department of Supply and Services through its Unsolicited Proposals Program; Transport Canada, including the Transportation Development Centre in Montreal; Environment Canada; Indian and Northern Affairs; and the governments of the Yukon and Northwest Territories).

The objectives of this study are to improve existing and develop new methods of controlling drifting snow across highways, in order to improve highway safety, and to reduce maintenance costs associated with snow removal. In order to meet these objectives, a literature search, a survey of highway departments and a number of highway site visits were conducted.

The first step taken in the study was to conduct a literature search to determine the state-of-the-art methods currently used for snow control. With the use of a direct computer link at RWDI's office and at the University of Guelph, most major data bases located in North America were accessible. In total, 381 references on ice and snow control were identified and approximately 30 of these were obtained and reviewed.

The loss of traction due to icing of the highway surface, reduced visibility due to snow blowing across the highway, and snow accumulations on the highway are all examples of types of snowdrifting problems. In order to classify which of these problems or other types of problems is most important and consequently should receive the most time to develop solutions, a questionnaire was mailed to 162 highway departments throughout Ontario, Quebec, New Brunswick, the Yukon and the Northwest Territories. Of the 162 questionnaires that were mailed out, approximately 70% were completed and returned to our office.

Each roads department was also asked if they would be interested in participating in the research study by providing sites and installing the agreed solution. After a preliminary screening process, interested departments were contacted by telephone to further discuss the problem sites. Ultimately 35

SOMMAIRE

Ce rapport a été préparé par Rowan Williams Davies & Irwin Inc. (RWDI) de Guelph, Ontario et financé par quatre organismes fédéraux et deux gouvernements territoriaux (Approvisionnements et Services Canada par le biais de son Programme des propositions spontanées; Transports Canada incluant le Centre de développement des transports de Montréal; Environment Canada; Ministère des Affaires indiennes et du Nord canadien; le Yukon et les Territories du Nord-Ouest).

Les buts poursuivis consistaient à améliorer les méthodes actuelles de contrôle d'accumulation de la neige et à en développer de nouvelles dans l'intention de rendre les autoroutes plus sécuritaires et de réduire les coûts d'entretien associés au déblaiement de la neige. La consultation de bibliographies, des études du département des autoroutes et des visites de sites ont permis d'accomplir ces objectifs.

La première étape de cette étude a été de consulter des documents afin de déterminer quelles étaient les méthodes les plus élaborées utilisées actuellement pour contrôler l'accumulation de neige. L'accès à la plupart des banques de données d'Amérique du Nord fut rendu possible grâce aux lignes de communication directes des ordinateurs de l'Université de Guelph et de RWDI. Un total de 381 ouvrages relatifs au contrôle de l'accumulation de neige et de glace furent identifiés et parmi ceux-ci, 30 furent consultés.

Une perte de traction sur une route verglacée, une mauvaise visibilité causée par de la poudrerie, un amoncellement de neige sur les autoroutes sont quelques exemples communs de problèmes conséquents à l'accumulation de neige.

Un questionnaire fut envoyé à 162 départements des autoroutes au Québec, en Ontario, au Nouveau-Brunswick, au Yukon et dans les Territoires du Nord-Ouest afin de classer ces problèmes par ordre d'importance et d'établir par conséquent des priorités dans la recherche d'une solution. A peu près 70% des questionnaires envoyés furent complétés par ces départements et renvoyés à nos bureaux.

Les services de voirie furent également invités à participer à ce projet de recherche en procurant des informations précises sur des sites et en mettant en place les solutions approuvées. Après un premier examen des données, les départements en question furent contactés par téléphone afin de discuter, en

sites were chosen and studied over a three-year duration.

Standard procedures were developed to ensure that similar information was gathered during each site visit.

In order to determine the effectiveness of a solution, it was decided to select a similar reference site near to the study site. By recording depths at both sites, the improvement observed due to the addition of a solution, was gauged against the reference site which did not have a solution installed.

Since it was realized that significant snowdrifting conditions would occur at these sites when our inspector could not observe them, it was agreed by the participating roads departments to make periodic observations which would be recorded in a log book.

The observer selected was an individual who regularly viewed the site. This person was directed to record the results only after a significant snowfall or drifting event. The essential observations were to see if the control device had filled with snow and if the site experienced any change in drifting conditions when compared to previous winters. All log books were reviewed with the observer when site visits were made and at the end of the winter they were returned to our office to be added to our files.

In order to establish prevailing wind directions and critical snow information at the sites, 15 representative weather stations were selected to provide this background information.

Initially, the data gathered and analyzed at each weather station included the following:

1) mean snowfall (cm)
2) wind direction with wind speed greater than 15 km/h
3) blowing snow wind direction
4) winds greater than 15 km/h accompanying snowfall

All of this information is summarized in tables and wind roses for each station. This information was analyzed to determine long term averages which were compared to annual data recorded for each of the study years.

plus amples détails, les sites problématiques. Finalement, un total de 35 terrains furent sélectionnés et soumis à l'étude pendant une période de 3 ans.

Des normes de procédure furent établies afin que les mêmes données soient prélevées lors de chaque visite de site.

Un site similaire proche de celui étudié fut utilisé comme référence afin d'évaluer l'efficacité d'une solution. Une comparaison entre la hauteur de neige accumulée au site où la solution avait été mise en place et la hauteur de neige accumulée au site de référence, intact, permirent de quantifier l'amélioration apportée par la mise en place de la solution.

Les services de voirie ont accepté de procéder à des contrôles réguliers et d'inscrire les informations prélevées dans un registre puisque notre inspecteur ne pouvait pas toujours être présent sur le site lors de conditions de poudrerie.

La personne choisie comme responsable de l'observation visita régulièrement le site et fut chargée de collecter les données seulement à la suite d'une chute de neige ou de conditions de poudrerie importantes. L'essentiel était de vérifier la quantité de neige accumulée par le système de contrôle et de déterminer les variations quant à l'amoncellement de neige sur le terrain par rapport aux hivers précédents. Chaque registre fut vérifié, après chaque visite de site, avec la personne responsable de l'observation et furent ensuite classés dans nos dossiers à la fin de l'hiver.

Quinze stations météorologiques furent choisies afin d'apporter des informations quant aux directions des vents dominants et quant aux chutes de neige pour les sites étudiés.

A l'origine, les données en provenance de chaque station météorologique regroupaient les éléments suivants:

1) Chute de neige moyenne (cm)
2) Direction et vitesse des vents dépassant 15 km/h
3) Direction du vent déplaçant la neige
4) Vents de vitesse supérieure à 15 km/h accompagnant une chute de neige

Chacune de ces informations est condensée dans des tables et roses des vents pour chaque station météorologique. Elles ont permis d'établir des moyennes à long terme qui furent ensuite comparées aux données résultant d'études annuelles.

The use of annual peak ground snow cover was used as well as mean annual snowfall to design snowfence heights. An additional comparison was made between the mean annual snowfall and the four year peak ground snow cover. The average ratio of mean annual snowfall to four year peak ground snow cover is 3.8:1. Therefore, if the 4 year peak ground cover was not available, then using approximately 1/4 of the annual snowfall was a reasonable estimate.

Lastly, the average number of degree days below 0°C per winter month was observed to determine the type of snowdrifting that could be expected to occur.

After each study site was identified, the site was visited with a highway department official(s) familiar with the snowdrifting problems typically experienced to gather first hand information about the site.

After the problem identification site visit was conducted, the data gathered (both site and meteorological) was used to develop solutions. In many cases, the participating highways department was interested in permanent solutions but would have required more time than the study would permit to both install and to acquire funding. As a result, temporary snowfencing was substituted to determine the effectiveness of the barrier. To design these fences, the most crucial information needed is the amount of snow which blows towards a site. Essentially the amount of snow blowing towards a site is dependent on the wind speed and direction, the amount of snowfall and the amount of open terrain (fetch) upwind of the site.

The volume of snow can be calculated. However, current methods apply to Arctic and Prairie regions which do not receive as many freeze/thaw cycles throughout the winter.

Some of the sites studied experience these cycles. It is our experience that the calculation using mean annual snowfall overstates the problem. It was found that using the four year peak ground snow cover instead of the mean annual snow fall resulted in a more realistic estimate of snow transport for sites which experience freeze/thaw cycles.

Les notions de hauteur maximale de neige au sol et hauteur moyenne annuelle de chute de neige furent employées pour la détermination des hauteurs des clôtures à neige. Des comparaisons supplémentaires entre la hauteur moyenne de chute de neige annuelle et la hauteur maximale de neige au sol pour une période de quatre ans ont conduit à définir un rapport entre ces deux paramètres de 3,8:1. Lorsque la hauteur maximale de neige au sol pour une période de quatre ans n'était pas disponible, l'approximation égale à 1/4 de la hauteur moyenne de chute annuelle fut employée et jugée comme une approximation raisonnable.

En dernier lieu, la moyenne du nombre de degrés-jours au dessous de 0° pendant les mois d'hiver fut prise en considération afin de définir les types de conditions de poudrerie pouvant se produire sur le site considéré.

Une fois le site désigné, il fut visité par un (des) représentant(s) officiel(s) du département des routes, familiarisé(s) avec les problèmes d'accumulation de neige et les techniques utilisées pour rassembler les informations sur le site.

Après cette visite d'identification du site problématique, les données rassemblées (tant au point de vue des conditions de terrain que des conditions météorologiques) furent exploitées dans le but de développer des solutions. Dans beaucoup de cas, les départements des routes participant à cette étude étaient intéressés à la mise en place de solutions à long terme dont le coût et le délai requis pour leur installation étaient plus importants que ceux que l'étude ne le permettait. Dès lors, des clôtures à neige temporaires furent installées pour évaluer l'efficacité des barrières. L'information primordiale requise était la quantité de neige déplacée vers le site. Celle-ci dépend principalement de la direction et de la vitesse du vent, de la hauteur de la chute de neige et de l'étendue du terrain situé face au vent par rapport au site ("fetch").

Le volume de neige accumulé peut être calculé. Cependant, les méthodes actuelles de calcul s'appliquent aux régions de l'Arctique et des Prairies qui ne sont pas sujettes aux nombreux cycles de gel-dégel en hiver.

Ces cycles se sont produits pour quelques-uns des sites étudiés. Notre expérience démontre que l'utilisation de la notion de chute de neige moyenne annuelle supprime l'influence de ce facteur.
L'utilisation de la notion de hauteur maximale de neige au sol pour une période de quatre ans à la place de la hauteur de neige moyenne annuelle offre une meilleure approximation du déplacement de la neige pour les sites sujets aux cycles de gel-dégel.

It is pointed out, however, that due to less than typical winters during this study and limited available data for Eastern Canada, the methods used to calculate snow transport may not be fully accurate. Therefore, some caution is expressed when using the four year Peak Ground Snow Cover to determine snowfence sizes.

Once the amount of snow transport is known, the appropriate fence height can be determined.

Having designed the fence height, the setback and overlap dimensions found in the literature search were used. Typically the setback distances used were 30 times the fence height from any critical area when placing a fence in an Arctic/Prairie scenario and 15 times the fence height for snowdrifting conditions more typical of Eastern Canada.

After a solution was designed and installed, a site visit was conducted to measure the resultant snow accumulations at each study and reference site. In order to assess if a solution was effective, observations made by the highway crews and the RWDI inspector are considered.

When considering sites which experience numerous freeze/thaw cycles, the calculated snow transport volume each year exceeds the measured volume by approximately 2 to 4 times. The four year peak ground snow cover method appears more appropriate than the mean snowfall method which exceeds the measured amounts by 9 to 17 times. It is recommended that further studies be conducted to verify these results and to further research the appropriate return period for the peak ground snow cover and/or any other parameters that are appropriate.

It was found that snow fences in Eastern Canada have snow drifts which extend approximately 15 times their height. In addition, it is also concluded that snowfences located in Arctic Regions have snowdrifts which extend approximately 30 times their height downwind of the fence.

It was determined that locations experiencing more than 15 degree days below 0°C per month are generally Arctic/Prairie locations and those with less than 15 degree days below 0°C per month are representative of Eastern Canadian climates.

Less than typical snowdrifting conditions occurred at most study sites which resulted in many solutions not being fully tested.

Il est important de noter que les méthodes utilisées pour le calcul du transfert de la neige sont d'une précision limitée dû aux hivers inhabituels observés durant cette étude et au nombre limité de données en provenance de l'Est du Canada. Dès lors, une attention particulière est recommandée lors de l'utilisation de la hauteur maximale de neige au sol pour une période de 4 ans afin de déterminer les hauteurs des clôtures à neige.

Dans la mesure où l'on connaît le déplacement de la neige, il est facile d'établir la hauteur adéquate des clôtures à neige.

Une fois les hauteurs de clôtures définies, les distances de recul et de recouvrement furent établies après consultations bibliographiques. De façon générale, la distance de recul typique déterminée pour les régions arctiques et les Prairies est de 30 fois la hauteur de la clôture et de 15 fois la hauteur de la clôture pour les conditions rencontrées dans l'Est du Canada.

Après le choix et la mise en place d'une solution, une visite du site fut effectuée afin de déterminer les hauteurs de neige sur le site modifié et le site de référence. Les observations faites par les équipes d'entretien des autoroutes et par l'inspecteur de RWDI furent utilisées afin d'établir l'efficacité d'une solution.

Le volume de neige déplacé établi par calcul est de deux à quatre fois supérieur à celui mesuré dans les régions sujettes à de nombreux cycles gel-dégel.

L'utilisation de la notion de hauteur maximale de neige au sol pour une période de 4 ans est plus appropriée que la hauteur moyenne de chute de neige annuelle qui excède de neuf à dix-sept fois la quantité mesurée. Il est recommandé que des études complémentaires s'étendant sur de plus longues périodes soient menées afin d'affiner ces données et d'autres paramètres jugés nécessaires.

Il fut établi que les clôtures à neige installées dans l'Est du Canada éparpillent la neige sur une distance égale à approximativement quinze fois leur hauteur tandis que cette distance sera approximativement égale à trente fois leur hauteur pour celles installées dans les régions arctiques.

De plus, il fut déterminé que les sites présentant plus de 15 degrés-jours par mois sont généralement localisés dans l'Arctique et les Prairies, ceux présentant moins de 15 degrés-jours par mois étant situés dans l'Est du Canada.

Des conditions anormales de poudrerie furent rencontrées pour la plupart des sites étudiés ce qui eut pour conséquence qu'un grand nombre de solutions ne furent pas complètement mises à l'épreuve.

In conditions where a snowfence was placed directly on the ground, it filled with snow faster than if elevated above the ground.

Snowfences taller than 1.2m high and/or in windy locations require lateral bracing to resist wind loads.

Some solution failures were as a result of improper installation methods.

When the prevailing wind was not at right angles to a road and the snowfence installed was located parallel to the road, the fence collected less snow than a fence which was located at right angles to the wind.

Cut sections located adjacent to highways cause snowdrifting problems. Regrading the backslopes is not always sufficient to significantly reduce snowdrifting on the highway. Due to the open exposure upwind of a site, the source of driftable snow still exists even if the cut has been streamlined. Particularly where high traffic volumes occur, this snow can still be packed onto the road surface causing reduced traction.

Lorsque la base des clôtures à neige fut mise en contact direct avec le sol, celles-ci se remplirent plus vite de neige que lorsque la base de ces dernières fut élevée par rapport au niveau du sol.

Les clôtures à neige d'une hauteur supérieure à 1,2 mètre nécessitent un support latéral afin de résister au vent.

Les échecs rencontrés furent quelquefois la cause d'une installation inadéquate.

La quantité de neige récoltée fut maximale lorsque la direction des vents dominants était perpendiculaire à la clôture.

Les sections de déblai adjacentes à la route provoquent des problèmes de poudrerie. La réduction des pentes n'est parfois pas suffisante pour réduire en conséquence les problèmes de poudrerie sur les autoroutes. La source de neige disponible pour provoquer de la poudrerie est toujours présente si le site est toujours exposé à de larges étendues ouvertes après que la modification de la pente ait pris place. Cette accumulation de neige peut provoquer des problèmes de pertes de traction pour les routes où le trafic est dense.

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E - Log Book Example

F - Meteorological Data

1. INTRODUCTION

This report has been prepared by Rowan Williams Davies & Irwin Inc. (RWDI) Guelph, Ontario as a co-operative venture funded by four federal departments and two territorial governments (Department of Supply and Services through its Unsolicited Proposals Program; Transport Canada, including the Transportation Development Centre in Montreal; Environment Canada; Indian and Northern Affairs; and the governments of the Yukon and Northwest Territories).

The objectives of this study are to improve existing and develop new methods of controlling drifting snow across highways, in order to improve highway safety, and to reduce maintenance costs associated with snow removal.

In order to meet these objectives, a literature search, a survey of highway departments and a number of highway site visits were conducted. The literature search and survey assisted in determining the direction of the study and the selection of the study sites. Initially, over 35 sites were visited in Ontario, Quebec, the Yukon and Northwest Territories to identify typical problem conditions. After this first winter (1986-87), the Province of Quebec was only able to support installing solutions at 2 of the 13 chosen sites. Therefore, it was decided to include sites within the Province of New Brunswick during the second winter after viewing the study sites during the summer and fall of 1987 to discuss the problems experienced during previous winters.

The problem conditions were reviewed along with local meteorological data to develop solutions during the summer of 1987 which were installed at each site prior to the winter of 1987-88. However, due to a less than typical winter (1987-88) for snowdrifting at most of the sites, it was agreed by Transport Canada to extend the study for another winter (1988-89). In some cases, the solutions installed during the 1987-88 winter needed adjustment to improve their snow control efficiency. After the data was collected, it was analyzed to produce this report along with guidelines to be used by roads department staff to reduce snowdrifting on highways.

2. LITERATURE/INFORMATION SEARCH

The first step taken in the study was to conduct a literature search to determine the state-of-the-art methods currently used for snow control. Our Progress Report for this task was submitted July 3, 1987 and the main body of that report is included in Appendix A of this report. With the use of a direct computer link at RWDI's office and at the University of Guelph, most major data bases located in North America were accessible. In total, 381 references on ice and snow control were identified and approximately 30 of these were obtained and reviewed of which 8 are summarized in Appendix A of that report. Perhaps the best reference document is titled "Snowdrifts and Winter Ice on Roads" by T.R. Schneider which is a Technical Translation published by the National Research Council of Canada, Ottawa, in July 1962. Although over 25 years old, the snowdrift related problems, causes, and various forms of control described in the report, are also observed in current times. Even the solution concepts used in the early 1960's are still applied over two decades later. Drift control measures such as regrading, snowfences, trees, hedgerows and earth or snow berms are among the solution concepts presented.

3. SITE SELECTION

The loss of traction due to icing of the highway surface, reduced visibility due to snow blowing across the highway and snow accumulations on the highway are all examples of types of snowdrifting problems. In order to classify which of these problems or other types of problems is most important and consequently should receive the most time to develop solutions, a questionnaire was mailed to 162 highway departments throughout Ontario, Quebec, New Brunswick, the Yukon and the Northwest Territories to ask a number of these and other questions. An example of this questionnaire is included in Appendix B of this report. Of the 162 questionnaires that were mailed out, approximately 70% were completed and returned to our office.

Due to the lack of responses from New Brunswick, the Yukon and the Northwest Territories, the summaries shown in the following tables were only completed for the provinces of Ontario and Quebec for the regions shown in Figure 1. These regions were chosen based on their geographical location and known weather conditions as they relate to drifting snow.

Province	Ontario					
Region	**All**	**1**	**2**	**3**	**4**	**5**
1. Questionnaires						
a) number sent out	113	15	48	23	12	15
b) number returned	83	12	38	14	8	8
2. Winter Maintenance Costs						
a) $ per km of highway	3103	1515	3298	4285	1809	3397
b) % by activity						
i sand/salt application	43	48	43	33	46	38
ii snow plowing	26	24	27	33	34	21
iii snow removal	11	9	10	15	4	18
iv snowfence removal and installation	2	2	4	2	2	1
v snow blowing	2	-	1	10	2	1
vi other	16	17	15	7	12	21
3. Is snowfencing a practical solution to control drifting snow?						
a) yes	75	42	89	69	50	75
b) no	25	58	11	31	50	25
4. Rating of most critical snow related problems (%)						
a) snow accumulation	25	25	22	38	13	29
b) reduced visibility	14	-	15	19	25	14
c) traction	59	75	59	43	62	57
d) other	2	-	4	-	-	-

TABLE 1A

QUESTIONNAIRE SUMMARY - ONTARIO

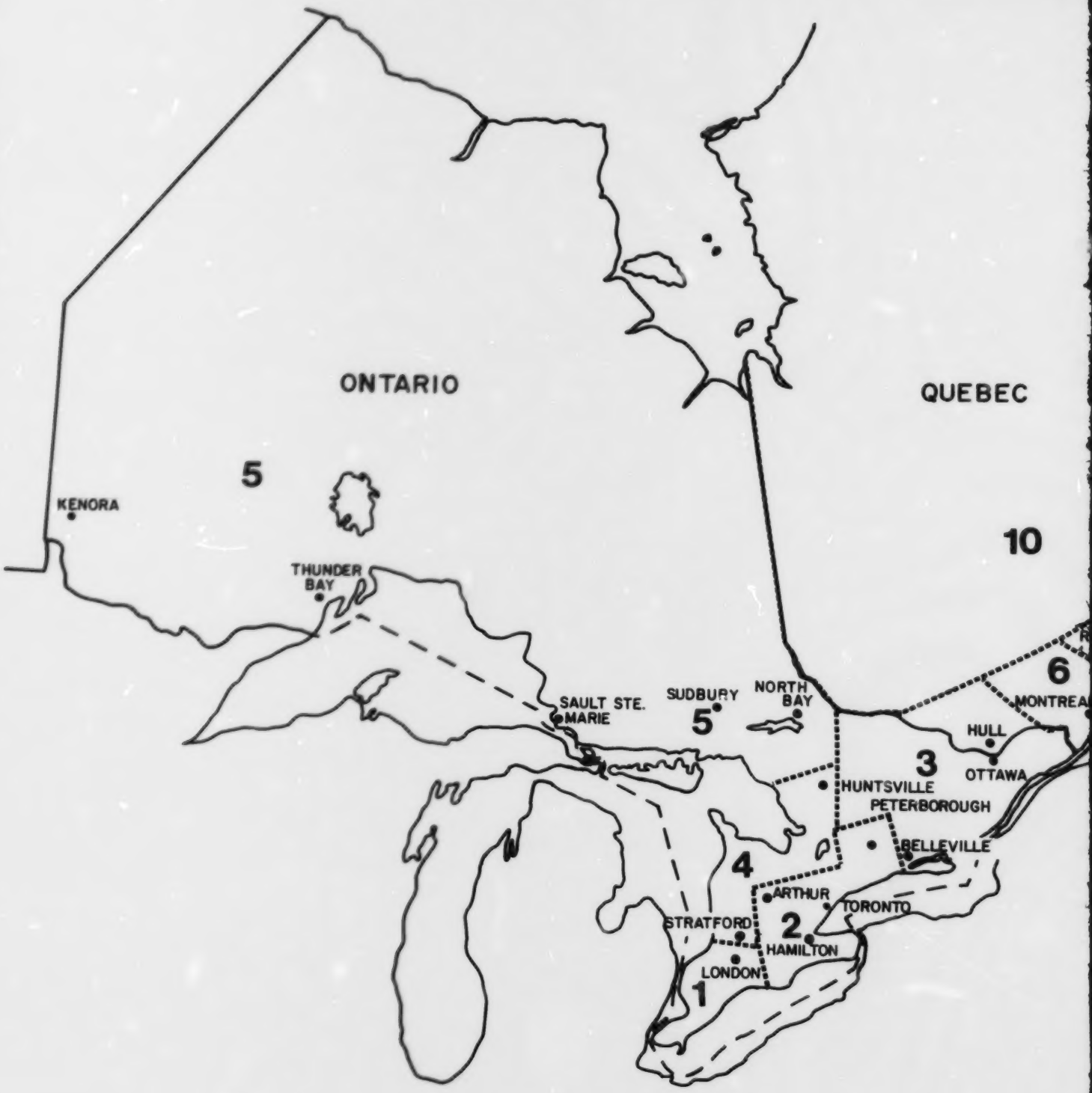

ONTARIO
QUEBEC
5
KENORA
THUNDER BAY
10
SAULT STE. MARIE
SUDBURY
5
NORTH BAY
6
MONTREA
HULL
OTTAWA
3
HUNTSVILLE
PETERBOROUGH
BELLEVILLE
4
ARTHUR
TORONTO
STRATFORD
2
HAMILTON
LONDON
1

FIGURE 1

PROVINCIAL REGIONS FOR
HIGHWAY SNOWDRIFTING STUDY

APPROX. SCALE 1:8000

RVDI

Province		Ontario					
Region		All	1	2	3	4	5
5.	Annual frequency of most critical condition (%)						
	a) less than 10 times	22	17	31	23	13	14
	b) 10 to 20 times	36	49	33	46	13	29
	c) 20 to 30 times	16	17	25	-	13	-
	d) more than 30 times	26	17	11	31	61	57
6.	Summer maintenance program to correct snow related problems						
	a) yes						
	i respondents	29	5	12	6	3	3
	ii percentage	38	42	32	46	38	43
	b) no						
	i respondents	48	7	25	7	5	4
	ii percentage	62	58	68	54	62	57
7.	Types of solutions used and percent frequency of use (from those answering yes to 6.)						
	a) erecting permanent snowfencing	-	-	-	-	-	-
	b) regrading of backslopes	23	8	26	30	33	-
	c) planting ground cover	4	8	5	-	-	-
	d) planting shelterbelts	8	-	11	8	17	17
	e) pruning of existing trees	16	-	21	8	-	50
	f) elevating road	16	34	8	23	33	-
	g) removing/relocating fence rows	23	25	24	23	17	-
	h) changing type of guardrail	1	-	-	-	-	17
	i) relocating obstructions	10	25	5	8	-	17

TABLE 1B

QUESTIONNAIRE SUMMARY - ONTARIO

Province		Quebec					
Region		All	6	7	8	9	10
1.	Questionnaires						
	a) number sent out	49	25	9	6	7	2
	b) number returned	32	14	6	5	4	1
2.	Winter Maintenance Costs						
	a) $ per km of highway	4255	4712	3871	3535	4822	5568
	b) % by activity						
	i sand/salt application	31	27	43	19	42	28
	ii snow plowing	35	27	35	23	35	45
	iii snow removal	9	11	3	17	7	-
	iv snowfence removal and installation	1	1	-	3	-	-
	v snow blowing	12	27	13	12	5	-
	vi other	12	7	6	26	11	27
3.	Is snowfencing a practical solution to control drifting snow?						
	a) yes	31	27	60	-	25	100
	b) no	69	73	40	100	75	-
4.	Rating of most critical snow related problems (%)						
	a) snow accumulation	30	33	20	40	25	-
	b) reduced visibility	20	25	-	20	-	100
	c) traction	43	33	80	20	75	-
	d) other	7	9	-	20	-	-

TABLE 2A

QUESTIONNAIRE SUMMARY - QUEBEC

Province		Quebec					
Region		All	6	7	8	9	10
5.	Annual frequency of most critical condition (%)						
	a) less than 10 times	39	40	60	40	-	-
	b) 10 to 20 times	25	40	20	20	-	-
	c) 20 to 30 times	14	10	-	20	50	-
	d) more than 30 times	22	10	20	20	50	100
6.	Summer maintenance program to correct snow related problems						
	a) yes						
	i respondents	6	3	1	1	-	1
	ii percentage	23	27	20	20	-	100
	b) no						
	i respondents	20	8	4	4	4	-
	ii percentage	77	73	80	80	100	-
7.	Types of solutions used and percent frequency of use (from those answering yes to 6.)						
	a) erecting permanent snowfencing	11	-	-	-	-	50
	b) regrading of backslopes	22	25	-	-	-	50
	c) planting ground cover	-	-	-	-	-	-
	d) planting shelterbelts	22	-	-	50	-	-
	e) pruning of existing trees	-	-	-	-	-	-
	f) elevating road	11	-	-	50	-	-
	g) removing/relocating fence rows	11	25	-	-	-	-
	h) changing type of guardrail	-	-	-	-	-	-
	i) relocating obstructions	22	50	-	-	-	-

TABLE 2B

QUESTIONNAIRE SUMMARY - QUEBEC

Along with the above information, each roads department was also asked if they would be interested in participating in the research study by providing sites and installing the agreed solution. After a preliminary screening process, interested departments were contacted by telephone to further discuss the problem sites. Then in an effort to reduce travel costs, sites were paired in a general vicinity making sure that each site had a different type of problem. The number of sites studied for at least one winter totalled 55. Due to various complications, primarily a lack of funding to install solutions at a number of sites, replacements were required to achieve the objective of 35 sites. The following is the list of sites to be used in this study, having been the most effective and/or being studied for the most number of winters.

Ontario

1) 1-1 Bruce County Road #1 - Paisley
2) 1-2 Highway 24 - Hornings Mills
3) 1-3 Highway 91 - Stayner
4) 1-4 Highway 100 - London
5) 1-5 Highway 100 - London
6) 1-6 Wellington County Road 32 - Guelph
7) 1-8 Crumlin Side Road - London
8) 1-9 Jalna Blvd. - London
9) 1-10 Peel Regional Road 7 - Sandhill
10) 1-11 Kettleholes - Sudbury
11) 1-12 Regional Road 86 - Sudbury Airport
12) 1-13 Foster Drive Park - Sault Ste. Marie
13) 1-14 Highway 550 - Sault Ste. Marie
14) 1-16 Grey County Road 1 - Owen Sound
15) 1-17 Prince of Wales Drive - Ottawa
16) 1-18 Ottawa Carleton Regional Road 3
17) 1-19 Fallowfield Road - Ottawa
18) 1-20 Steeles Avenue at 5N and 5S - Milton
19) 1-23 Dufferin County Road 3 - Orangeville
20) 1-26 Wellington County Road 18 - Elora
21) 1-27 Grey County Road 7, McKnight Farm - Meaford
22) 1-28 Grey County Road 4, Caswell's Cut - Meaford

Quebec

23) 3-6 Route 55 - Interchange at Route 108, Sherbrooke
24) 3-11 Route 20 - La Pocatiere

Northwest Territories

25) 5-3 Dempster Highway Km 4.0
26) 5-4 Dempster Highway Km 28.5

Yukon Territory

27) 7-1 Dempster Highway Km 265.0
28) 7-2 Dempster Highway Km 106.0

New Brunswick

29) 9-1 Trans Canada Highway, South of Palmer Road - Woodstock
30) 9-2 Trans Canada Highway - Waterville
31) 9-3 Route 560, South of McQuarry Road - Woodstock
32) 9-4 Trans Canada Highway, Tantramar Marsh - Aulac
33) 9-5 Route 15, Emery Leger Road - Cape Pele
34) 9-6 Route 11, North of Sunset Drive - Bathurst
35) 9-7 Route 11 - Janeville

4. SITE OBSERVATION METHODOLOGY

As shown in Appendix C, standard procedures were developed to ensure that similar information was gathered during each site visit. As well, cameras were used wherever possible to gather data. In fact, the "data back" on the camera was not used to record the date but instead record the site number. The site numbers on the photo indicated first the province, the site and then the year. Since generally only one site visit was made to collect data, towards the end of each winter, the year was adequate to differentiate between visits and the first two numbers differentiate between the sites. The following are the Province/Territory numbers.

1 - Ontario Study Site
2 - Ontario Reference Site
3 - Quebec Study Site
4 - Quebec Reference Site
5 - NWT Study Site
6 - NWT Reference Site
7 - Yukon Study Site
8 - Yukon Reference Site
9 - New Brunswick Study Site
10 - New Brunswick Reference Site

In order to determine the effectiveness of a solution, it was decided to select a similar reference site near to the study site. By recording depths at both sites, the improvement observed due to the addition of a solution, was gauged against the reference site which did not have a solution installed. The reference site for any study site has the same number as the study site except for the first number. The reference site number is always the even number and the study site the odd number (see above list).

To record snow depths, a 1/2" diameter pipe was used to probe down to ground level. The pipe was striped in 10 cm intervals and made of interconnecting sections of pipe, 1m long (see Figure 2). Beginning at either the edge of the road or the snowfence, the depths were measured every metre, working further from the start point until measurements were a constant depth. The depths were initially tape recorded and later, indoors, transcribed onto the record sheets. The locations of the measurements were recorded on the record sheets as well as by placement of markers at the site to ensure that the measurements were made at the same location each year. As the depths were measured, the location was marked with a 15 by 30 cm black card partially inserted into the snow. Once a series of measurements were made, the cards were photographed for future use during data analysis (see Figure 2). All information observed for each site visit was recorded on a checklist also intended to ensure consistency in recording information at each site (see Appendix C). In some cases, the snow was too hard to fully probe, so the cards were inserted every metre and a 2m high (black and yellow) reference pole was erected at the shoulder of the road to gauge the depth of the snow by projecting the level of the card across to the pole (see Figure 2). The information gathered at each of the 35 study sites is summarized in Appendix D.

Since it was realized that significant snowdrifting conditions would occur at these sites when our inspector could not observe them, it was agreed by the participating roads departments to make periodic observations which would be recorded in a log book. A completed example of this log is shown in Appendix E.

The observer selected was an individual who regularly viewed the site. This person was directed to record the results only after a significant snowfall or drifting event. The essential observations were to see if the control device had filled with snow and if the site experienced any change in drifting conditions when compared to previous winters. It was anticipated that, if the device filled, a problem condition would develop. In most cases, the log books were filled out. In other cases they were not, for various reasons, usually due to the remoteness of the site from the observers office. However, as in the example shown in Appendix E, a number of log books also included photos and detailed notes. All log books were reviewed with the observer when the site visits were made and at the end of the winter they were returned to our office to be added to our files.

5. METEOROLOGICAL DATA

In order to establish prevailing wind directions and critical snow information at the sites, representative weather stations were selected to provide this background information. These stations are as follows:

1) Charlo, New Brunswick
2) Fredericton, New Brunswick
3) London, Ontario
4) Moncton, New Brunswick
5) Mount Forest, Ontario
6) Ottawa, Ontario
7) Riviere Du Loup, Quebec
8) Sault Ste. Marie, Ontario
9) Sherbrooke, Quebec
10) Sudbury, Ontario
11) Toronto, Ontario
12) Waterloo, Ontario
13) Wiarton, Ontario
14) Inuvik, NWT
15) Whitehorse, Yukon

Initially, the data gathered and analyzed at each weather station included the following:

1) mean snowfall (cm)
2) wind direction with wind speed greater than 15 km/h
3) blowing snow wind direction
4) winds greater than 15 km/h accompanying snowfall

All of this information is summarized in tables and wind roses for each station in Appendix F. This information was analyzed to determine long term averages which were compared to annual data

1/2" DIA. PROBE WITH MARKER

STRIPED 2m REFERENCE POLE WITH MARKERS

FIGURE 2
SNOW MEASUREMENT APPARATUS

recorded for each of the study years. The wind roses give an indication of the similarity of the wind directions but do not indicate how many hourly observations of blowing snow or snowfall with wind occurred. Therefore, these data sets were further analyzed to determine the hours of occurrence of these conditions. The summary of this data is shown in Tables F-1 to F-3 in Appendix F. Due to a limited budget for meteorological analysis and the extension of the project for an additional winter, these tables do not include results for the 1988-89 winter. By comparing the computed mean to that reported for the individual year, it is easy to determine if the year was above or below average for the data set analyzed.

As will be discussed later in this report, the use of annual peak ground snow cover was used as well as mean annual snowfall to design snowfence heights. As will be discussed in Section 7, the four year peak ground snow cover may be used to calculate the fence height needed to protect a particular site. Table F-4 presents this information along with the peak ground snow cover at each weather station during each of the three study years. The following method was used to calculate the four year peak ground snow cover: Multi-year data indicating actual measured peak ground snow cover was used to obtain a Normal Distribution curve of ground snow vs. probability. These probabilities were calculated for specific snow depths and using the inverse (1/probability) gives the return period for any given amount of snow. These values were then plotted on a Normal/Log scale of the amount of snow vs. return period in years. A best fit curve was computed and the amount of snow was then taken from the graph where the four year peak ground snow cover intersects the curve.

Similar to Tables F-1 to F-3, a simple comparison of information across the table shows if a particular winter is above or below the 4 year peak ground snow cover.

An additional comparison was made between the mean annual snowfall and the four year peak ground snow cover for Eastern Canadian sites. The results of this analysis are shown in Table F-6. The average ratio of mean annual snowfall to four year peak ground snow cover is 3.8:1. Therefore, if the four year peak ground cover was not available, then using approximately 1/4 of the annual snowfall was a reasonable estimate. For locations in Arctic and Prairie regions, the mean annual snowfall should be used as described in Reference 7.

Lastly, the average number of degree days below 0°C per winter month was observed to determine the type of snowdrifting that could be expected to occur. It is the authors' experience that temperature generally causes three different snowdrifting conditions to occur in Canada. They are as follows:

1) little or no drifting due to a lack of snowfall
2) typical snowdrifting conditions (Eastern Canada)
3) Arctic/Prairie snowdrifting conditions

Using the above parameters, the average degree days below 0°C per winter month were analyzed for 97 Canadian cities and presented in Table F-5 of Appendix F. These values range from less than 1 to 30 degree days below 0°C per month. It is our experience that locations in Southern Ontario, like Hamilton (Reference 8), do not experience significant amounts of snowfall. From Table F-5, cities located in these areas have four degree days or less below 0°C per month.

It is the authors' experience that in Arctic/Prairie regions, unlike many of the areas of Eastern Canada, weather conditions do not usually exist where freeze/thaw cycles occur throughout the winter as observed at Sites 5-1 to 5-4, 7-1 and 7-2. From observing Table F-5, Arctic and Prairie locations typically experience 15 or more degree days below 0°C each month. Although this theory requires further research, it could be concluded that areas which experience four degree days or less per winter month will not be likely to have significant snowdrifting conditions annually while locations experiencing 15 or more degree days below 0°C per winter month will experience Arctic/Prairie type drifts which are very hard and typically 30 times as long as the height of the obstruction causing them (Reference 7). In comparison, snowdrifts which are typical in Eastern Canada are not as hard and approximately 15 times the height of the obstruction causing them (Reference 2). These drifts could be observed in locations which receive less than 15 degree days below 0°C each winter month.

6. PROBLEM IDENTIFICATION

After each study site was identified, the site was visited with a highway department official(s) familiar with the snowdrifting problems typically experienced. Included in the discussions with this individual(s) were: the type of solutions which have been tried at the site; which of these solutions were successful in solving the problem; other solutions which may be effective in solving the problem and; do they have funds in their budget to install solutions. A summary of the information gathered at each site is included in Appendix D.

In order to compare the consistency of weather conditions from winter to winter, an uncontrolled reference site was selected near the study site. This site was carefully chosen in a location that would, itself, have a problem condition similar to the study site.

7. SOLUTION DEVELOPMENT

After the problem identification site visit was conducted, the data gathered (both site and meteorological) was used to develop solutions. In many cases, the participating highways department was interested in permanent solutions but would have required more time than the study would permit to both install and to acquire funding. As a result, temporary snowfencing was substituted to determine the effectiveness of the barrier. To design these fences, the most crucial information needed is the amount of snow which blows towards a site. Essentially the amount of snow blowing towards a site is dependent on the wind speed and direction, the amount of snowfall and the amount of open terrain (fetch) upwind of the site.

The volume of snow (snow transport) can be calculated and methods described in References 6 and 7 are the most applicable. However, these methods apply to Arctic and Prairie regions which do not receive as many freeze/thaw cycles throughout the winter.

Most of the sites studied experience these cycles. It is our experience that the calculation using mean annual snowfall, overstates the problem (Section 9). Therefore, using the above method in Eastern Canada the snow transport calculation would reflect a higher volume of snow than actually occurs. Initially the volume of snow was arbitrarily reduced by half and the resultant fence height used. However, further study of peak ground snow cover was conducted to determine a more realistic snow transport. It was found that using the 4 year peak ground snow cover instead of the mean annual snow fall resulted in a more realistic estimate of snow transport. Results from this analysis are presented in Section 9.

Therefore, depending on whether the site is located in an Arctic/Prairie region (15 or more degree days below 0°C per month) or eastern regions (less than 15 degree days below 0°C per month) the mean annual snowfall or 4 year peak ground snow cover would be applied to the following equation to determine the snow transport to any given fetch distance.

$$Q_t = 0.5\ PT\ (1 - 0.14^{F/T})$$

where:

Q_t = snow transport, water equivalent, volume per unit width of site (cubic metres of water per metre width of site).

P = relocated precipitation (water equivalent in metres). This is the mean annual snowfall (Arctic/Prairie region) or the peak ground snow cover in a 4 year return period. (eastern Canada region). These calculations assume a 1:10 ratio of water to snow equivalent.

T = maximum transport distance (metres)
= 3048 metres

F = fetch or contributing distance (metres)

By applying the appropriate information to this equation, various snow transport rates can be determined for the two precipitation parameters and various fetch lengths.

Knowing the snow transport, the following equation can be used to determine the appropriate fence height.

$$H = 0.39\ Q_t^{0.459}$$

where

H = height of fence (metres)

Having designed the fence height, the setback and overlap dimensions found in the literature search were used (References 1, 2, 6 and 7). Typically the setback distances used were 30 times the fence height from any critical area when placing a fence in an Arctic/Prairie scenario and 15 times the fence height for snowdrifting conditions more typical of Eastern Canada. For examples of fence arrangements used, see Appendix D.

8. SOLUTION ASSESSMENT

After a solution was designed and installed, a site visit was conducted to measure the resultant snow accumulations at each study and reference site. In order to assess if a solution was effective, a number of comparisons were made as follows:

1) A comparison of meterological data to determine if the current winter was typical of an average winter or 4 year return peak ground snow cover.

2) A comparison of snow accumulations at the reference site to depths measured at the study site.

3) A comparison of snow accumulations at the reference site to similar measurements during prior years.

4) A comparison of snow accumulations at the study site to similar measurements during the year(s) prior.

In addition, observations made by the highway crews and the RWDI inspector are considered in the assessment. An assessment for each site can be found in Appendix D.

9. CONCLUSIONS

From the observations made during this study the following conclusions have been made:

1) The most difficult aspect in designing snow control devices is to determine the volume of drifting snow approaching a site. To date, the best method devised is by R.D. Tabler (References 6 and 7). However, this method has been developed for colder climates than Eastern Canada (i.e. Prairie and Arctic regions) that do not experience as many freeze/thaw cycles during the winter. To modify the calculations used, it was found that using the 4 year peak ground snow cover in place of the mean annual snowfall more closely matched the snow accumulations measured in various snow fences. Table 3 on the next page uses sites in eastern Canada to demonstrate these adjusted calculations. The sites chosen experienced less than typical snowdrifting conditions. As a result, the measured snow volumes (in cubic metres/linear metre of site) are less than the design volumes.

   Although the calculated volume each year still exceeds the measured volume on average 2.4 times. The 4 year peak ground snow cover method appears more appropriate than the mean snowfall method which exceeds the measured amounts on average 11.1 times. It is recommended that further studies be conducted to verify these results and to further research the appropriate return period for the peak ground snow cover and/or any other parameters that are appropriate.

2) It was found that snow fences in Eastern Canada have snow drifts which extend approximately 15 times their height as illustrated in Figure 3. In addition, it is also observed that snowfences located in Arctic Regions have snowdrifts which extend approximately 30 times their height downwind of the fence as shown in Figure 3.

3) As it would appear that the mean snowfall method of calculated snow transport is appropriate in Arctic/Prairie regions and the peak ground snowfall method is appropriate for Eastern Canadian climates, a method was needed to determine which location is Eastern Canadian and which is Arctic/Prairie. It was decided to analyze the number of degree days below 0° C per winter month for a number of Canadian cities (Table F-5 in Appendix F). From this analysis, it was determined that locations experiencing more than 15 degree days per month are generally Arctic/Prairie locations and those with less than 15 degree days per month are representative of Eastern Canadian climates.

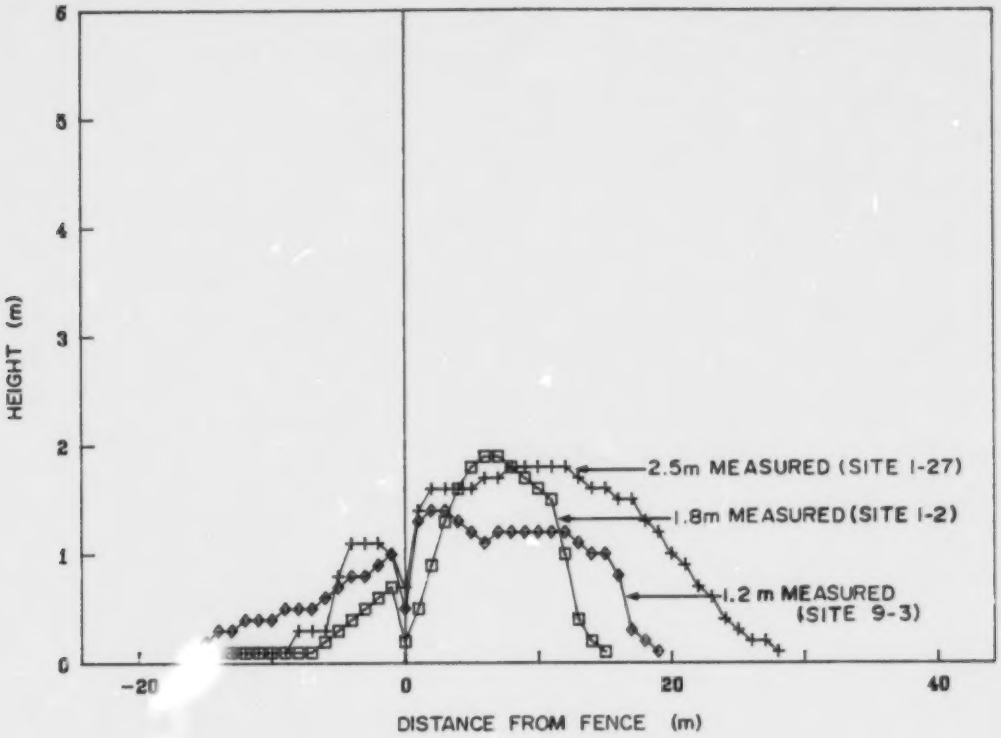
4) It can also be concluded that less than typical snowdrifting conditions occurred at most study sites which resulted in many solutions not being fully tested.

Site	Mean Snowfall Method						4 year Peak Ground Cover Method					
	1987-88			1988-89			1987-88			1988-89		
	Cal. Vol.	Mea. Vol.	Ratio	Cal. Vol.	Mea. Vol.	Ratio	Cal. Vol.	Mea. Vol.	Ratio	Cal. Vol.	Mea. Vol.	Ratio
1-12 Sudbury Ont.	973	53	18.4:1	883	46	19.1:1	256	53	4.8:1	256	46	5.6:1
1-14 S.S. Marie Ont.	263	29.2	9.0:1	269	18.6	14.5:1	41	29.2	1.4:1	49	18.6	2.6:1
1-16 Owen Sound Ont.	297	13	22.8:1	-	-	-	56	13	4.3:1	-	-	-
1-27 Meaford Ont.	-	-	-	388	39.8	9.7:1	-	-	-	41	39.8	1.1:1
1-28 Meaford Ont.	297	42	7.1:1	388	46	8.4:1	56	42	1.3:1	41	46	0.9:1
9-1 Woodstock N.B.	218	24.8	8.8:1	195	23.3	8.4:1	56	24.8	2.3:1	21	23.3	0.9:1
9-2 Waterville N.B.	218	33.7	6.5:1	195	23.9	8.2:1	56	33.7	1.7:1	21	23.9	0.9:1
9-5 Cape Pele N.B.	326	51	6.4:1	-	-	-	56	51	1.1:1	-	-	-
9-6 Bathurst N.B.	647	71	9.1:1	606	69	8.8:1	188	71	2.6:1	188	69	2.7:1
9-7 Janeville N.B.	647	59.2	10.9:1	606	50.8	11.9:1	188	59.2	3.2:1	188	50.8	3.7:1

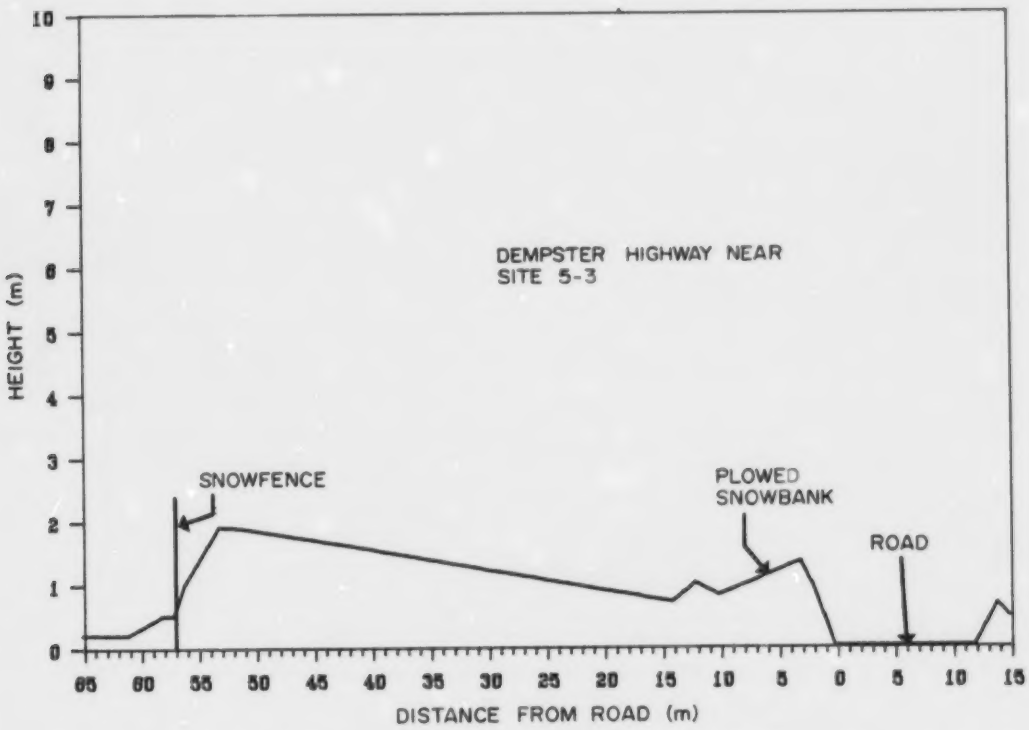
TABLE 3

COMPARISON OF SNOWFENCE DESIGN METHODS

(Volumes are for snow transport in m^3/m site length)



VARIOUS SNOWFENCE HEIGHTS – EASTERN CANADA LOCATION – MARCH 1989



2.5m HIGH SNOWFENCE – ARCTIC / PRAIRIE LOCATION – MARCH 1987

FIGURE 3

SNOWFENCE DRIFT PROFILES

5) In conditions where the snowfence was placed directly on the ground, it filled with snow faster than if elevated above the ground.

6) Snowfences taller than 1.2m high and/or in windy locations require lateral bracing to resist wind loads.

7) Some solution failures were as a result of improper installation methods which involved locating the solution, erecting fencing, securing fences to posts, lateral bracing and conveying information to field crews.

8) When the prevailing wind was not at right angles to a road and the snowfence installed was located parallel to the road, the fence collected less snow than a fence which was located at right angles to the wind.

9) It has been known that cut sections located adjacent to highways cause snowdrifting problems. However, regrading the backslopes is not always sufficient to significantly reduce snowdrifting on the highway. Due to the open exposure upwind of a site, the source of driftable snow still exists even if the cut has been streamlined. Particularly were high traffic volumes occur this snow can still be packed onto the road surface causing reduced traction.

10. RECOMMENDATIONS

The following are recommendations reached as a result of this study.

1) Further study is recommended to verify if the peak ground snow cover method is the most applicable to calculate snow transport. It may be necessary to explore other parameters which are more applicable. Knowing that the 4 year peak ground snow cover, the degree days below 0°C and blowing snow wind directions are not easily obtained, exploring other methods which involve information more easily obtained would be preferred.

2) It is recommended that snowfences used in Eastern Canadian climates be installed using a setback distance which is a minimum of 15 times the fence height.

3) It is recommended that snowfences used in Arctic/Prairie climates be installed using a setback distance which is a minimum of 30 times the fence height.

4) It is recommended that locations having more than 15 degree days below 0°C per winter month be considered as Arctic/Prairie regions and locations having less than 15 degree days per winter month be considered as having Eastern Canadian climates. However, further study is recommended to verify the parameters used.

5) It is recommended that this study be extended to add more data to refine the above recommendations. The study sites could be reduced to about ten to observe conditions in selected areas.

6) Snowfences should be elevated above grade when installed. Based on guidelines presented in Reference 7, 1.2m high fences should be raised 15 cm; 1.8m high fences 25 cm and 2.5m high fences 30 cm high.

7) The following post spacing is provided as a guideline for various fence heights. Lateral bracing is suggested for both sides of the fence at every other post. This spacing is largely based on successful fence installations for the sites studied.

   1.2m high fence - posts spaced 5m apart
   1.8m high fence - posts spaced 3m apart
   2.5m high fence - posts spaced 2 - 3m apart

8) It is recommended that standard installation methods be adopted by each roads department that respond to the equipment and manpower available as well as site conditions. These methods should be reviewed and updated regularly to ensure the optimum solution is being used,

9) It is recommended, where snowfencing is being installed in park areas, that pedestrian access be provided (see Figure D-8-1, Appendix D).

10) Where creeks, streams, rivers, etc. flow through a site where snowfencing is being installed, it is recommended that openings be provided to avoid damming of the spring melt water which could cause localized flooding.

11) It is recommended that snowfences be installed at right angles to the wind to maximize collection capacity. As a result, the traditional installation of fences parallel to the highway may need to be replaced with angled arrangements as shown in Appendix D.

12) It is recommended that where trees are used for snow control that they be continuous plantings over the length of the problem site. The planting should be inspected annually to ensure that openings have not developed and that large gaps between the ground and the lower branches do not exist.

14) It is recommended that when regrading a cut, the backslope should be reduced to 7:1 or less. In addition, snowfencing should be considered upwind of the cut to reduce the drifting snow which could be packed onto the road surface.

11. REFERENCES

1) Williams, C.J. and Baker, H.A., "Guidelines for Controlling Snowdrifting Problems Along Ontario Highways", submitted to MTC of Ontario, June 1986.

2) Schneider, T.R., "Snowdrifts and Winter Ice on Roads", a technical translation (#TT1038) published by the National Research Council of Canada, Ottawa, July 1962.

3) Magnetic Meteorological Tapes obtained from Atmospheric Environment Service, Toronto, for the following weather stations:

   1) Charlo, New Brunswick
   2) Fredericton, New Brunswick
   3) London, Ontario
   4) Moncton, New Brunswick
   5) Mount Forest, Ontario
   6) Ottawa, Ontario
   7) Riviere Du Loup, Quebec
   8) Sault Ste. Marie, Ontario
   9) Sherbrooke, Quebec
   10) Sudbury, Ontario
   11) Toronto, Ontario
   12) Waterloo, Ontario
   13) Wiarton, Ontario
   14) Inuvik, NWT
   15) Whitehorse, Yukon

4) Environment Canada, "Canadian Climate Normals Volume 3 - Precipitation 1951 - 1980".

5) Environment Canada, "Canadian Climate Normals Volume 4 - Degree Days 1951 - 1980.

6) Tabler, R.D., "Preliminary Design Criteria for Snow Fences on Alaska's North Slope", June 9, 1976.

7) Tabler, R.D., "Snow Fence Handbook" Release 1.0 Tabler & Associates, Wyoming, 1986.

8) Baker, H.A. and Anderson, S.R., "Snow Control Study Mountain East-West and North-South Transportation Corridor, Hamilton, Ontario" submitted to Freeway Project Office, The Regional Municipality of Hamilton-Wentworth, June 6, 1989.

9) Baker, H.A. and Williams, C.J., "Snow Control Study Honda of Canada Manufacturing Plant Test Track, Alliston, Ontario" submitted to Honda of Canada Manufacturing Inc., June 2, 1986.

APPENDIX A

PROGRESS REPORT

TASK 1 - LITERATURE/INFORMATION SEARCH
RESEARCH STUDY OF HIGHWAY SNOWDRIFTING
D.S.S. FILE NO. 4852 T8200-6-6542

Report 48712192
July 3, 1987

Submitted to:
TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA
MONTREAL, QUEBEC

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3. SEARCH METHODOLOGY	2
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5. BIBLIOGRAPHIC REFERENCES	6

APPENDICES

A - CAN/OLE AND DIALOG Data Base Addresses
B - CISTI List of Alternate Reference Libraries
C - Snow Control Bibliographic References
D - Ice Control Bibliographic References

1. INTRODUCTION

Rowan Williams Davies & Irwin Inc. (RWDI) have been contracted by Supply and Services Canada (DSS) to conduct a research study of highway snowdrifting in Canada. The objective of this study is to improve existing methods of controlling drifting snow across highways and to develop new methods which will ultimately improve highway safety and reduce maintenance costs associated with snow removal. This report summarizes the literature search/review, which was undertaken as Task 1 in this project and provides 381 references on ice and snow control.

2. DATA BASES

The search for information was undertaken through a direct computer link, at RWDI's office and at the University of Guelph, to major data bases located in North America. In RWDI's office, the CAN/OLE data base enquiry system, available through National Research Council's Canadian Institute for Scientific and Technical Information (CISTI) in Ottawa, was used to access a number of data bases, 10 of which provided applicable references. At the University of Guelph, a data base enquiry sytem known as DIALOG provided five data bases with relevant bibliographies. A list of names and addresses of the data bases which contained relevant bibliographic references is included in Appendix A.

By using the CAN/OLE and DIALOG computer data bases, virtually all ice and snow control related papers have been located in major North American data bases. However, one must be aware that a number of small libraries exist, which may contain articles relating to site specific studies or research programs. For instance, engineering based universities would be a likely source for additional references, or even private firms, such as RWDI, who conduct tests or research projects on snowdrifting. Federal and Provincial ministries or agencies, such as Public Works Canada, Department of Public Works or Transport Canada for instance, should contain a number of reports on snowdrift control studies, both site specific and general in nature.

CISTI publishes a list of a number of alternative reference sources available across Canada. This list has been reproduced in Appendix B of this report. In the list, the first one or two letters of each library name code refer to the province.

3. SEARCH METHODOLOGY

In searching for articles in the on-line computer data bases, sets of references (search sets) which contain key search words in the title or keyword list, are created. By combining two or more search sets, the relevant references can be isolated. The following summarizes the strategy used to search and retrieve the references provided in this report. An asterisk beside a word indicates that all derivatives of the word were also searched for.

SEARCH SET #	SEARCH WORDS OR SEARCH STRATEGY
1	Street*, Highway*, Road*
2	Snow*, Ice*, Blizzard*, Storm*, Whiteout*, Drift*, Traction*
3	This set contains references with one word from Set 1 and one word from Set 2
4	Fence*, Hedgerow*, Berm*, Landscaping, Collection, Shelterbelt*
5	This set contains references with one word from each of Sets 1, 2 and 4 which were not already contained in Set 3

4. LITERATURE REVIEWS

Approximately 30 of the articles provided as references in the search were obtained and reviewed. The following is our summary of the highlights of eight of the articles which provided the most interesting information on ice/snow control measures or techniques.

4.1 "SNOWDRIFTS AND WINTER ICE ON ROADS" by T.R. Schneider. A Technical Translation (#TT 1038) published by the National Research Council of Canada, Ottawa, July 1962. 200 pages.

This report is perhaps the best reference document for this study as it addresses typical highway snowdrifting related problems, discusses the causes and presents various forms of control. Although the report is 25 years old, the snowdrift related problems and causes described in the report are also observed in current times. Even the solution concepts used back in the early 60's are still applied over two decades later. Hence, this report could be considered a true "State-of-the-Art" document. The report contains 60 pages on highway snowdrifting with 80 pages devoted to icing problems and methods of control. In addition, there are 111 illustrations and approximately 130 bibliographic references on a majority of the pioneering studies (dating back to 1902) conducted in this field. Drift control measures such as regrading, snowfences, trees, hedgerows, and earth or snowberms, are among the solution concepts presented. However, if one is interested in using snowfences or trees as a drift control measure, further research on these solutions has been conducted since 1962. Papers which present current technology on the use of snowfences or trees for drift control are discussed in a few of the following literature reviews.

4.2 "LIVING SNOWFENCES KEEP SNOW OFF THE ROAD" by Donald L. Comis, Soil and Water Conservation News, SCS, Washington, D.C., pg. 8 - 9, December 1983. Journal -U.S. Dept. of Agriculture and Soil Conservation Service, Volume 4 (9), December 1983.

This article describes how trees are used in lieu of snowfences to protect roads from drifting snow. The author states that three rows of evergreens are used with trees spaced 1.2 - 1.8 metres apart. The tree row closest to the road should be located at least 45 metres from the centreline of the road. Five tree rows were found to be as effective as tall 2 - 4 metre high wood slat snowfences.

4.3 "EFFICIENT SNOWFENCES HELP YOU CATCH THE DRIFT" by Mark Hurlbut - Tensar Corporation, published in Public Works for July 1986, pg. 58 - 60.

This is a good non-technical summary, written by a snowfence manufacturer/distributor, on snowfence research conducted over the past decade or so. Claims are made that snow removal costs have been reduced by up to 50% with snowfences and improved visibility has reduced accidents by as much as 70%. The author discusses the effects of items such as fence height, placement, porosity, etc.

4.4 "DESIGN CRITERIA AND LOCATION OF SNOW FENCES" by Harold Norem - Norwegian Geotechnical Institute, Oslo, Norway. Published in Anals of Glaciology, Volume 6, 1985, pg. 68 - 70.

This paper is more of a brief technical overview of the design and location of snowfences. Nine literature references were cited as sources for the snowfence design information.

4.5 "SNOW DEFLECTOR BUILT AT THE EDGE OF A ROAD CUT" by Yutaka Anno published in Cold Regions Science and Technology - Volume 12, No. 2, April 1986, pg. 121 - 129.

Discussion on the innovative use of a solid snow deflector fence to protect a road cut in Honshu, Japan. Severe drifting conditions were previously experienced in the road cut with a 4m deep snowdrift blocking the road 5 - 6 times per winter. Through scale model testing in a wind tunnel, a 4.1m tall by 470m long solid deflector fence (wall) with a 30° downwind incline was developed. A prototype was constructed in the field and placed at the upwind edge of the road. With the deflector fence in place there were no road blockages, road surface visibility was improved and snow removal costs were reduced by 1/3.

4.6 "CONTROL OF SNOW AND ICE IN HOKKADIO, JAPAN" by Seiiti Kinosita published in Journal of the Technical Councils of ASCE, Proceedings of the American Society of Civil Engineers - ASCE Volume 108, No. TC1, May 1982, pg. 34 - 43.

Methods used in Japan to control snow and ice on ships, roads, buildings, electric lines, etc. are discussed. For roads, solutions such as road sheds, collection snowfences, blower snowfences, or forest shelterbelts are used to control snowdrift related problems. The item of interest in this article is the photographs of an actual blower fence being used to increase the wind speed across a road surface thereby preventing snow deposition. Deicing methods employed include electric heating, warm water sprays and chemicals.

4.7 "ECONOMIC IMPACT OF HIGHWAY SNOW AND ICE CONTROL, STATE-OF-THE-ART" by Bob H. Welch et al. Prepared for Federal Highway Administration, Washington, D.C. Report No. FHWA-RD-77-20, September 1976. 293 pgs.

The report generally presents information on the economic impact on, for example, structural deterioration, maintenance, snowfences, traffic and safety etc. One key chapter for this study is one that discusses the effects of Sodium Chloride (Na Cl) deicing chemicals on vegetation survival. Included on pages 231 - 247 is an extensive listing of a number of species of trees and shrubs with their susceptability to sodium chloride rated. Plant susceptability to both salt spray and salt in soils is provided. This listing would be useful to assist in selecting snowdrift control plant material that would tend to be exposed to sodium chloride along side a roadway. The Report also contains 428 bibliographic references.

4.8 "THE USE OF A COMPUTER MODEL TO PREDICT THE FORMATION OF ICE ON ROAD SURFACES" by B.S. Parmenter & J.E. Thornes - Transport and Road Research Laboratory, Department of Transport, Crowtherne, Berkshire, U.K. 1986 Research Report 71. 19 pgs.

A seven year R & D project to develop an accurate means of predicting road surface icing through the use of road surface sensors, thermal mapping of road surfaces and computer analysis is described. In-situ tests revealed that use of conventional weather forecasts as a means of predicting icing conditions were accurate 57% of the time. The computer model proved that the inaccuracy of the conventional system would have wasted 32% of the total salt spread during the test period. This system can be applied to large districts or counties and is best suited to areas where average winter temperatures fluctuate around freezing.

5. BIBLIOGRAPHIC REFERENCES

The literature search located over 400 references; however, a large percentage of the references were related more specifically to ice control, deicing measures and techniques and environmental concerns of deicing chemicals. As both ice and snow control are both closely associated with winter highway maintenance, we have included most references on ice control. A good number of references on the environmental impact of deicing chemicals were, however, removed.

The reference section on Snow Control (Appendix C) presents 111 detailed bibliographies and includes several references on avalanche control. The reference section on Ice Control (Appendix D) presents less detailed information on 270 references. The data base(s) where the articles are retained are identified and indicated in CISTI's letter code system which is identified in the data base address list in Appendix A. As a rule, articles from any data base can be ordered through CISTI in Ottawa via an NRCC Deposit Account.

It is appropriate at this time to acknowledge the data bases referenced in this literature search report (Appendix A) in allowing their bibliographic references to be reproduced for this study. Most references, as reproduced in this report, are copyright protected and should not be reproduced further without written consent of the data base.

ROWAN WILLIAMS DAVIES & IRWIN Inc.

Bill F. Waechter, C.E.T.
Project Co-ordinator

Colin J. Williams, Ph.D. P.Eng.
Principal

APPENDIX B

APPENDIX B

QUESTIONNAIRE

REGARDING HIGHWAY SNOWDRIFTING IN CANADA

NAME: James I. Becking

TELEPHONE NUMBER: (613)560-1250

POSITION: Director of Operations

MUNICIPALITY: Regional Municipality of Ottawa-Carleton

PROVINCE: Ontario

1) What is your TOTAL annual winter maintenance budget?

$9,000,000.

_____ Not available.

2) Of your total winter maintenance budget, what percentage would be applied to the following activities?

39.9%	Sand/salt application (including material)
8.2%	Snow plowing
26.1%	Snow removal
3.5%	Snowfence installation and removal
.7%	Snow blowing
24.6%	All other activities
Standby road patrol, spring cleaning, cleaning catchbasins	
100%	Total

3) How many kilometres of highway does your department MAINTAIN?

_____	less than 100
_____	100 to 200
_____	200 to 300
_____	300 to 400
_____	400 to 500
_____	500 to 600
_____	600 to 700
_____	700 to 800
_____	800 to 900
_____	900 to 1000
X	more than 1000, specify 1053

4) Is it your opinion that snowfencing is a practical solution to control drifting snow in your area?

__X__ Yes
_____ No

Comments:

The "Yes" is qualified depending on the physical conditions of the situation.

5) Rate each of the listed snow related problems which affect your area of jurisdiction on the following scale:

0 - no problem
1 - minor problem
2 - problem
3 - severe problem

__X__ A. Snow accumulation on highways
__X__ B. Reduced visibility due to snow blowing across highways
__X__ C. Loss of traction due to icing of the highway surfaces
_____ D. Other (describe)

6) Indicate the most critical problem from item 5 (either A, B, C or D) and identify how often it occurs annually? A & C

_____ less than 10 times
__A__ 10 to 20 times
__C__ 20 to 30 times
_____ more than 30 times

7) Does your department have a summer maintenance program to correct snow related problems?

_____ Yes
__X__ No

If yes, which of the following measures has your department used?

_____ Erecting permanent snowfencing
_____ Regrading of backslopes
_____ Planting ground cover
_____ Planting shelterbelts
_____ Pruning existing trees
_____ Elevating road
_____ Removing/relocating fence rows
_____ Changing type of guardrail
_____ Relocating obstructions (i.e. utility poles, mail boxes, etc.)

8) Would your department be interested in participating in this research program with RWDI? (based on the following)

- you choose 2 or 3 typical problem sites
- RWDI staff member visit sites during February - March 1987
potential solution(s) are discussed with your appropriate staff members and details of an agreeable solution will be provided this spring or summer

- solution is implemented by your staff and at your cost before the winter of 1987/88
- RWDI staff will monitor solution during 1987/88 winter
- recommendations will be made to refine sclution if necessary

__X__ Yes
_____ No

9) Please indicate the type of solutions that would be considered for implementation by your department.

_____ Permanent snowfencing
__X__ Temporary snowfencing
__X__ Regrading of backslopes
_____ Planting ground cover
__X__ Planting shelterbelts
_____ Pruning existing trees
__X__ Elevating road
_____ Removing/relocating fence rows
_____ Changing type of guardrail
__X__ Altering plowing/removal methods
_____ Relocating obstructions (i.e. utility poles, mail boxes, etc.)

10) Do you have any areas of road construction which may be candidates for test sites?

__X__ Yes
_____ No

11) Has this been a typical "snow" winter?

_____ Yes
__X__ No

12) How soon could we proceed with a site visit?

Anytime.

13) Describe 2 or 3 potential study sites.

a. Open areas through to Experimental Farm on Prince of Wales Drive.

b. Farm areas along Regional Road 3 where the topography rises to the west and prevailing winds are from the West.

c. Sections of Woodroffe Avenue, Fallowfield Road and Greenbank Road within the Greenbelt.

APPENDIX C

STANDARD PROCEDURES

FOR

HIGHWAY SITE INVESTIGATIONS

GENERAL INFORMATION

SITE NUMBER - TO BE DETERMINED PRIOR TO SITE VISIT BY HAB

SITE NAME - USE NAME REFERRED TO BY FIELD CREWS (JONES CUT) OR NEARBY FARM (BROWN FARM)

SITE LOCATION - DESCRIBE LOCATION OF SITE IN RELATION TO A TOWN OR MAJOR ROAD INTERSECTION (1 Km SOUTH OF HWY 11 AND 42)

DISTRICT - NAME AND NUMBER TO BE DETERMINED BY HAB

REGION - NAME AND NUMBER TO BE DETERMINED BY HAB

PHOTOGRAPHS

- TAKE 35 mm COLOUR PRINTS OF SITE EXPOSURES (360' PAN)
- TAKE 35 mm COLOUR SLIDES OF PROBLEM CONDITION AT VARIOUS LOCATIONS IN PROBLEM AREA AND FROM DIFFERENT VANTAGE POINTS. (KEEPING IN MIND WE WILL BE TAKING BEFORE AND AFTER PHOTOS)
- INSERT STANDARD CARDS INTO SNOW AT 1 m INTERVALS ALONG STRIPE. STANDARD CARDS ARE 15 cm WIDE BY 30 cm LONG AND BLACK IN COLOUR. INSERT CARD SO THAT IT EXTENDS 15 cm ABOVE THE SNOW.
- A STANDARD REFERENCE STAKE 2 m HIGH TO BE STOOD ADJACENT TO ROAD AND DRIFT PROFILE .
- MAKE SURE ROAD IS IN PHOTOGRAPH, PARTICULARLY WHERE BEFORE AND AFTER COMPARISONS ARE TO BE MADE
- ROLL NUMBERS SHOULD INCLUDE SITE NUMBER (ie 3-1-1), THIS EXAMPLE WOULD INDICATE SITE NO. 3-1 AND ROLL NO. 1. IF A PART ROLL OF FILM IS USED FOR THE NEXT SITE, USE THE SAME NUMBER BUT IDENTIFY WHICH FRAMES APPLY TO THE NEW SITE.
- TRY TO TAKE PHOTOGRAPHS SO PREVAILING WIND GOES FROM LEFT TO RIGHT.

WEATHER CONDITIONS

- PRECISION IS NOT CRITICAL, APPROXIMATE TEMPERATURES ETC. ARE ADEQUATE.

SNOW CONDITIONS IN NEIGHBOURING FIELD

- DO NOT SPEND A LOT OF TIME MAKING THESE OBSERVATIONS, THE MOST CRITICAL ITEM IS 'THICKNESS OF SURFACE SNOW...'

METEOROLOGICAL DATA

- THIS INFORMATION SHOULD BE PREPARED BEFORE SITE VISIT TO FAMILIARIZE YOURSELF WITH PREVAILING WINDS ETC.
- ASK LOCAL CREW, SUPERVISOR ETC. ABOUT GENERAL DIRECTION OF WIND WHICH CAUSES PROBLEM.

PLAN OF STUDY SITE

- DIMENSIONS SHOULD BE IN METRIC FOR THIS STUDY
- PLAN SHOULD BE MADE WITH ENOUGH DETAIL TO ULTIMATELY LOCATE SOLUTIONS FROM A MAJOR FEATURE LIKE A HOUSE, UTILITY POLE ETC.
- INDICATE WHERE CROSS - SECTION (DEPTH MEASUREMENTS) WERE TAKEN, BOTH ON THE PLAN AND AT THE SITE

CROSS - SECTIONS OF STUDY AREA

- THESE CROSS - SECTIONS SHOULD BE SKETCHED TO INCLUDE THE APPROXIMATE DRIFT PROFILE.

SNOW DEPTH MEASUREMENTS - STUDY SITE

- APPROXIMATELY 3 PROFILES SHOULD BE TAKEN AT EACH STUDY SITE. LARGER SITES MAY REQUIRE MORE PROFILES.
- TYPICALLY, THESE PROFILES SHOULD BE TAKEN AT THE 1/4, 1/2 AND 3/4 POINTS ALONG THE PROBLEM AREA.
- MEASUREMENTS SHOULD BE TAKEN ALONG A LINE AT RIGHT ANGLES TO THE ROAD, STARTING AT THE EDGE OF THE ROAD (NOT THE SHOULDER) AND BE MADE AT 1 m INTERVALS. RECORD DEPTHS TO NEAREST TENTH OF A METRE.

SNOW DEPTH MEASUREMENTS - REFERENCE SITE

- CHOOSE A REFERENCE SITE CLOSE TO THE STUDY SITE
- ONE PROFILE OF SNOW DEPTHS SHOULD BE ADEQUATE
- THIS SITE IS TO BE USED AS A COMPARISON OF WINTER CONDITIONS FROM ONE YEAR TO THE NEXT, AS THE QUESTION MAY ARISE IN THE REMEDIAL SOLUTION PHASE, 'WERE THE TWO WINTERS SIMILAR?'.
- TRY TO CHOOSE A SITE WHICH HAS PERMENANT FEATURES (ie CHOOSE A CUT SECTION, NOT A SNOWFENCE AS THE INSTALLATION METHODS AND PLACEMENT FOR THE LATTER MAY VARY FROM YEAR TO YEAR)
- RECORD LOCATION OF PROFILE ON PLAN OF SITE AND MARK WITH PAINT, NAIL IN POST, ETC. AT THE SITE

R.W.D.I.

STANDARD SITE INVESTIGATION CHECKLIST

FOR

HIGHWAY SNOWDRIFTING

DATE: FEB 17/87

TIME START: 12⁰⁰ noon FINISH: 3:40pm

R.W.D.I. INSPECTOR: HAIS

GENERAL INFORMATION

SITE NUMBER: 1-1

SITE NAME: BROWN'S CUT – City Rd #1

SITE LOCATION: 2 km S.W. of PAISLEY

DISTRICT:

REGION: 1

PROVINCE: ONTARIO

PHOTOGRAPHS	SLIDES	PRINTS
	ROLL NUMBER: 1-1-1	ROLL NUMBER: 1-1-2
	FRAME NUMBERS: 1→13	FRAME NUMBERS: 1→24

WEATHER CONDITIONS

TEMP. -10° C

✓	CLEAR	___	SNOWING
___	PARTLY CLOUDY	___	BLOWING SNOW
___	OVERCAST	___	FREEZING
___	RAINING	___	THAWING

SNOW CONDITIONS IN NEIGHBOURING FIELD

___	CRUST SUPPORTS MAN ON ~~SNOWSHOES~~ → very dense snow
___	CRUST BREAKS UNDER MAN ON SNOWSHOES
___ cm	THICKNESS OF CRUST
___	SOFT AND POWDERY - NOT STICKY
< 1 cm	THICKNESS OF SURFACE SNOW, CAPABLE OF BEING DRIFTED
___	SOFT AND WET STICKY
___	GRANULAR

METEOROLOGICAL DATA (A.E.S. INFORMATION)

MEAN ANNUAL SNOWFALL:

MAXIMUM 24 HR. SNOWFALL:

PREVAILING WINTER WIND DIRECTION (%)

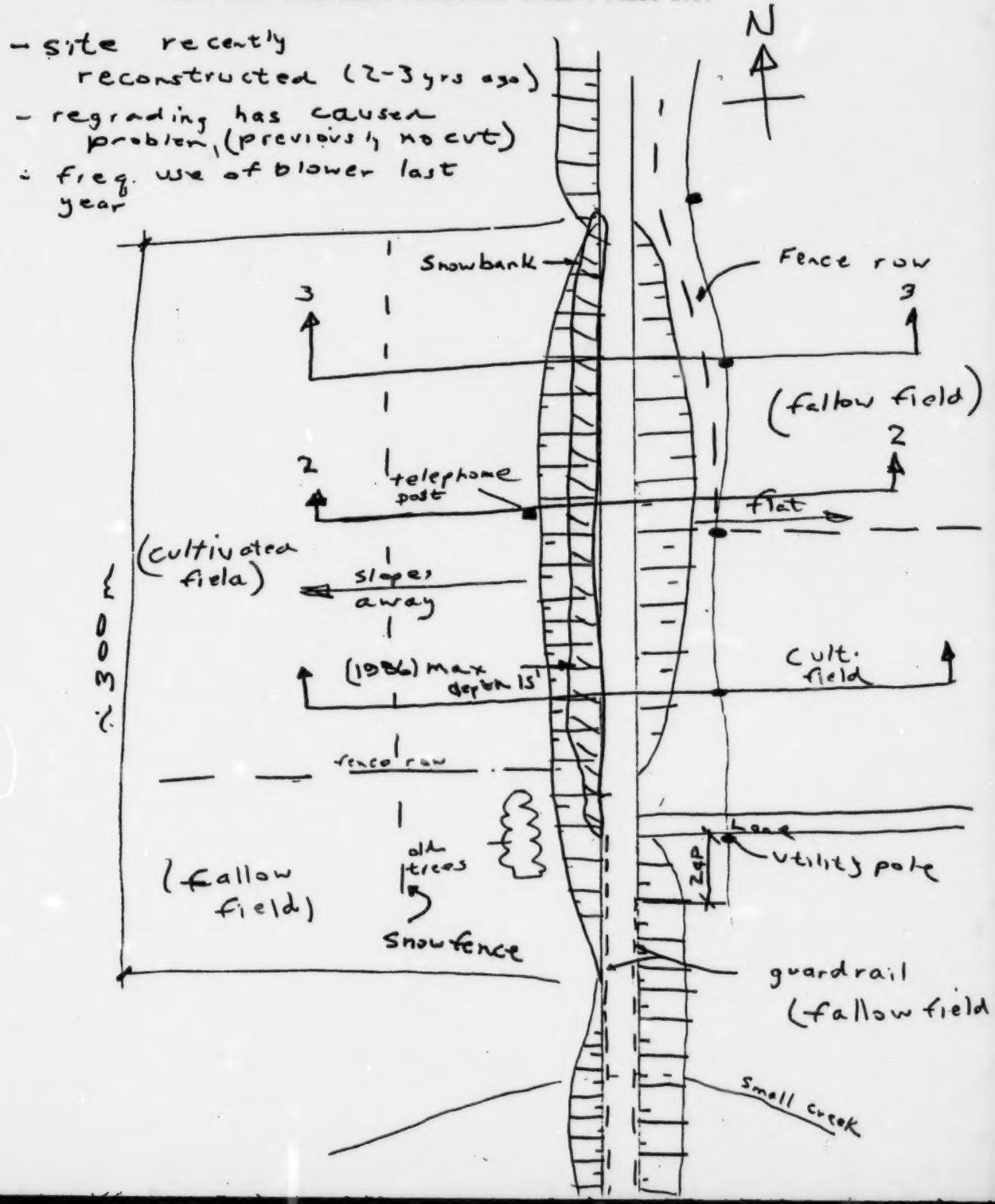
---- % NNE	---- % SSW
10 % NE	21 % SW
---- % ENE	---- % WSW
6 % E	13 % W
---- % ESE	---- % WNW
14 % SE	14 % NW
---- % SSE	---- % NNW
12 % S	8 % N

PROBLEM DIRECTIONS ACCORDING TO FIELD CREW:

- Southwest → west
- this winter not typical
  cut filled Last winter to appro

PLAN OF STUDY SITE

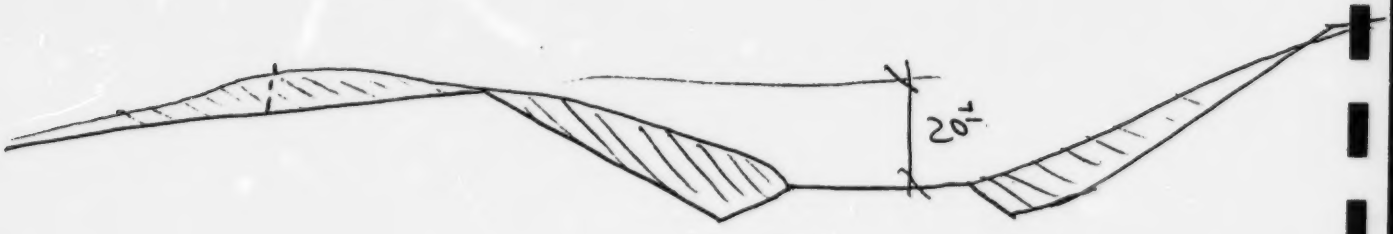
INCLUDE: -ORIENTATION
-EXPOSURES
-LOCATIONS OF PROBLEMS
-SOIL OR ROCK
-SIGNIFICANT LANDFORMS, BUILDINGS, UTILITY POLES ETC.



CROSS-SECTIONS OF STUDY SITE

*** CROSS REFERENCE WITH PLAN ON PAGE 3 ***

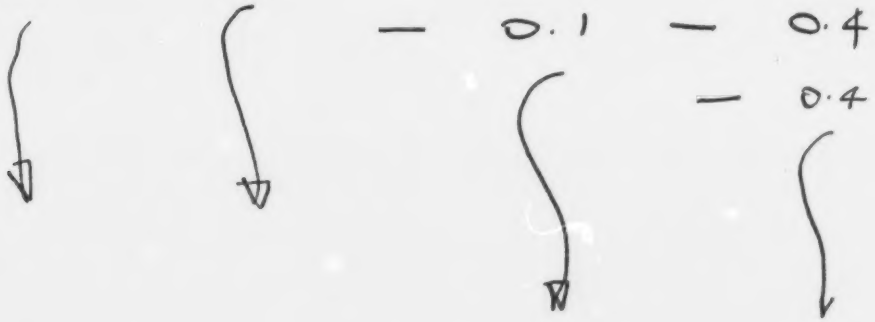
Typical Section



SNOW DEPTH MEASUREMENTS - STUDY SITE

LOCATION NO. -->	1	2	3	4	5	6
DISTANCE FROM ROAD (m)	0	0	0			
1	0	0	0			
2	0	0	0			
3	0.6	[illegible]	1.3			
4	(?) 1.5	1.6	2.2			
5	TD 2.1	1.5	2.7			
6	2.1	1.3	2.1			
7	1.8	1.2	1.8			
8	1.5	1.2	1.4			
9	1.1	1.1	1.0			
10	0.9	1.2	0.8			
11	0.7	1.2	0.4			
12	0.4	1.3	0.3			
13	(Ext. Cr) 0.2	1.2	0.2			
14	0.2	1.2	0.2			
15	0.2	1.0	0.1			
16	0.1	1.0	0.1			
17	0.1	0.6	0.1			
18	0.1	0.6	0.2			
19	0.2	0.4	0.2			
20	0.2	0.4 (TELE POST)	0.2			
21	0.2	0.5	0.2			
22	0.2	0.6	0.2			
23	0.2	0.7	0.3			
24	0.2	0.8	0.4			
25	0.4	0.7	0.5			
26	0.5	0.7	0.5			
27	0.5	0.8	0.6			
28	0.6	0.7	0.7			
29	0.6	0.8	0.8			
30	0.7	1.0	0.8			
31	0.7	1.2	0.9			
32	0.7	1.0	1.0			
33	0.7	1.2	1.0			
34	0.8	1.0	1.3			
35	0.8	1.2	1.2			
36	0.8	1.2	1.3			
37	0.6	1.2	1.3			
38	0.4	1.2	1.4			
39	0.6	1.0 - Fence	1.1 - Fence			

	1	2	3
40	0.5 (SNIOU LEENCG)	0.7	1.1
41	0.4	0.6	1.0
42	0.4	0.4	1.0
43	0.4	04	0.8
44	0.4	0.4	0.7
45	0.4	0.3	0.8
46	0.4	0.2	0.7
47	0.4	0.2	0.5
47	0.4	0.2	0.4
		0.1	0.4
			0.4



SNOW DEPTH MEASUREMENTS - REFERENCE SITE # 2-1

DISTANCE FROM ROAD (m)	SNOW DEPTH (m)
1	0
2	0.3
3	1.7
4	2.3
5	~~2.4~~ (?)
6	2.2
7	1.9
8	1.5
9	1.0
10	0.7
11	0.5
12	bldg ~~fence~~ ~~total~~ 0.4
13	0 "
14	
15	
16	
17	
18	
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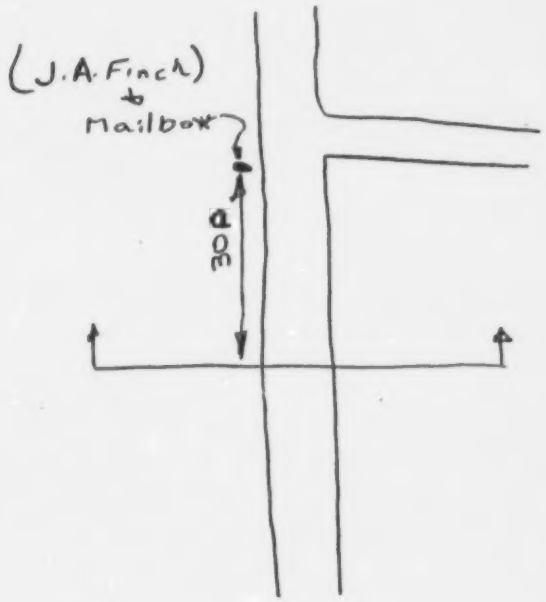
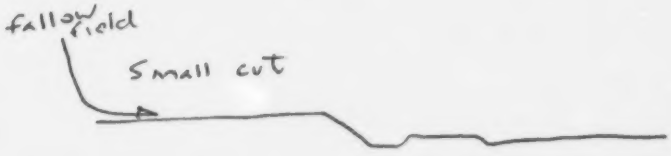
PLAN OF REFERENCE SITE

-INCLUDE DIRECTIONS TO FIND SITE FROM STUDY SITE.

- ref site approx. 0.5 km south of study site on Cty Rd #1



Plan



X-C

R.W.D.I.

SITE INVESTIGATION CHECKLIST

FOR SOLUTION ASSESSMENT

HIGHWAY SNOWDRIFTING STUDY

DATE: MAR 3/88

TIME START: 0:45 FINISH: 12:15 pm

R.W.D.I. INSPECTOR: HAB

GENERAL INFORMATION

SITE NUMBER: 1-1

SITE NAME: BROWN'S CUT - CTY RD #1

SITE LOCATION: 2km S.W of Paisley

DISTRICT:

REGION:

PROVINCE: ONTARIO

PHOTOGRAPHS

SLIDES
ROLL NUMBER: ~
FRAME NUMBERS:

PRINTS
ROLL NUMBER:
FRAME NUMBERS:

WEATHER CONDITIONS

TEMP. -5° C

- ~ CLEAR
- ____ PARTLY CLOUDY
- ____ OVERCAST
- ____ RAINING
- ____ SNOWING
- ____ BLOWING SNOW
- ~ FREEZING
- ____ THAWING

SNOW CONDITIONS IN NEIGHBOURING FIELD

- _____ CRUST SUPPORTS MAN ON SNOWSHOES
- _____ CRUST BREAKS UNDER MAN ON SNOWSHOES
- __ cm THICKNESS OF CRUST
- _____ SOFT AND POWDERY - NOT STICKY
- __ cm THICKNESS OF SURFACE SNOW, CAPABLE OF BEING DRIFTED
- ~ _____ SOFT AND WET STICKY
- _____ GRANULAR

METEOROLOGICAL DATA

1) HOW MUCH SNOW HAS FALLEN SO FAR THIS WINTER?

MORE THAN LAST YEAR

2) WHAT ARE THE PREVAILING WIND DIRECTIONS THIS WINTER?

SW, WSW

3) ARE THE SNOW CONDITIONS AT THIS SITE ANY DIFFERENT THAN PREVIOUS WINTERS?

TYPICAL, NOT AS SEVERE AS 2YRS AGO

4) COMMENTS FROM LOCAL MET. STATION:

OBSERVATIONS OF INSTALLED SOLUTION

1) WAS SOLUTION INSTALLED AS SHOWN IN SUPPLIED SKETCH? IF NOT INDICATE REVISED LAYOUT ON ATTACHED SKETCH.

YES, BUT ONLY 4FT HIGH

2) WAS SNOWFENCE ELEVATED AS RECOMMENDED?

NO

3) HAS FENCE SLIPPED DOWN POST?

—

4) RECORD DETAILS OF POST SPACING, SIZE, BRACING, FENCE ATTACHMENT, ETC.

4 WIREWOOD SLAT FENCING, 1.2m H., TBAR Posts, 5m spacing, 2 fastenings per post

5) HAS SNOWFENCE SUFFERED ANY VANDALISM?

—

6) HAS SNOWFENCE BEEN DAMAGED BY THE WIND?

—

COMMENTS AND OBSERVATIONS OF FIELD CREW:

- FENCE HAS IMPROVED VISIBILITY, REDUCED ACC. ON ROAD

SNOW DEPTH MEASUREMENTS - STUDY SITE

LOCATION NO. -->	①	②	③	④	⑤	⑥
DISTANCE FROM ROAD (m)				fence →		
0	0	0	0	0.4	0.2	0.5
1	0	0	0	0.3	0.6	0.7
2	0	0	0	0.2	0.8	1.0
3	1.4	0.7	0.4	0.2	0.5(?)	1.0
4	1.6	—	1.3	0.1	0.7	1.0
5	2.4	1.5	1.8		0.6	0.9
6	2.4	—	0.7		0.4	0.8
7	2.2	2.0	1.5		0.4	0.6
8	1.9	—	0.9		0.4	0.6
9	1.6	2.4	1.0		—	0.3
10	1.4	—	1.0		0.4	0.2
11	1.0	2.4	0.8		—	
12	0.8	—	0.7		0.4	
13	0.4	2.0	0.6		—	
14	0.3	—	0.8		0.2	
15	B.Fence 0.2	1.5	0.6 B.Fence			
16		—				
17		1.0				
18		—				
19		0.4				
20		—				
21		0.1 Tele.				
22		Boy				
23						
24						
25						
26						
27						
28						
29						
30						

SNOW DEPTH MEASUREMENTS - STUDY SITE

LOCATION NO. -->	(7)	(8)	9	10	11	12
DISTANCE FROM ROAD (m)	fence → 0.6	0.9				
1	0.4	0.9				
2	0.2	0.9				
3	0.2	0.9				
4		0.8				
5		0.7				
6		0.6				
7		0.6				
8		0.4				
9		0.3				
10		0.2				
11						
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SNOW DEPTH MEASUREMENTS - STUDY SITE

LOCATION NO. -->	13	14	15	16	17	18
DISTANCE FROM ROAD (m)						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
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SNOW DEPTH MEASUREMENTS - REFERENCE SITE

DISTANCE FROM ROAD (m)	SNOW DEPTH (m)
1	0
2	0.5
3	1.8
4	3.2
5	2.1
6	2.9
7	2.0
8	1.7
9	1.1
10	0.8
11	0.6
12	0.4
13 B Ferr...	0.1
14	
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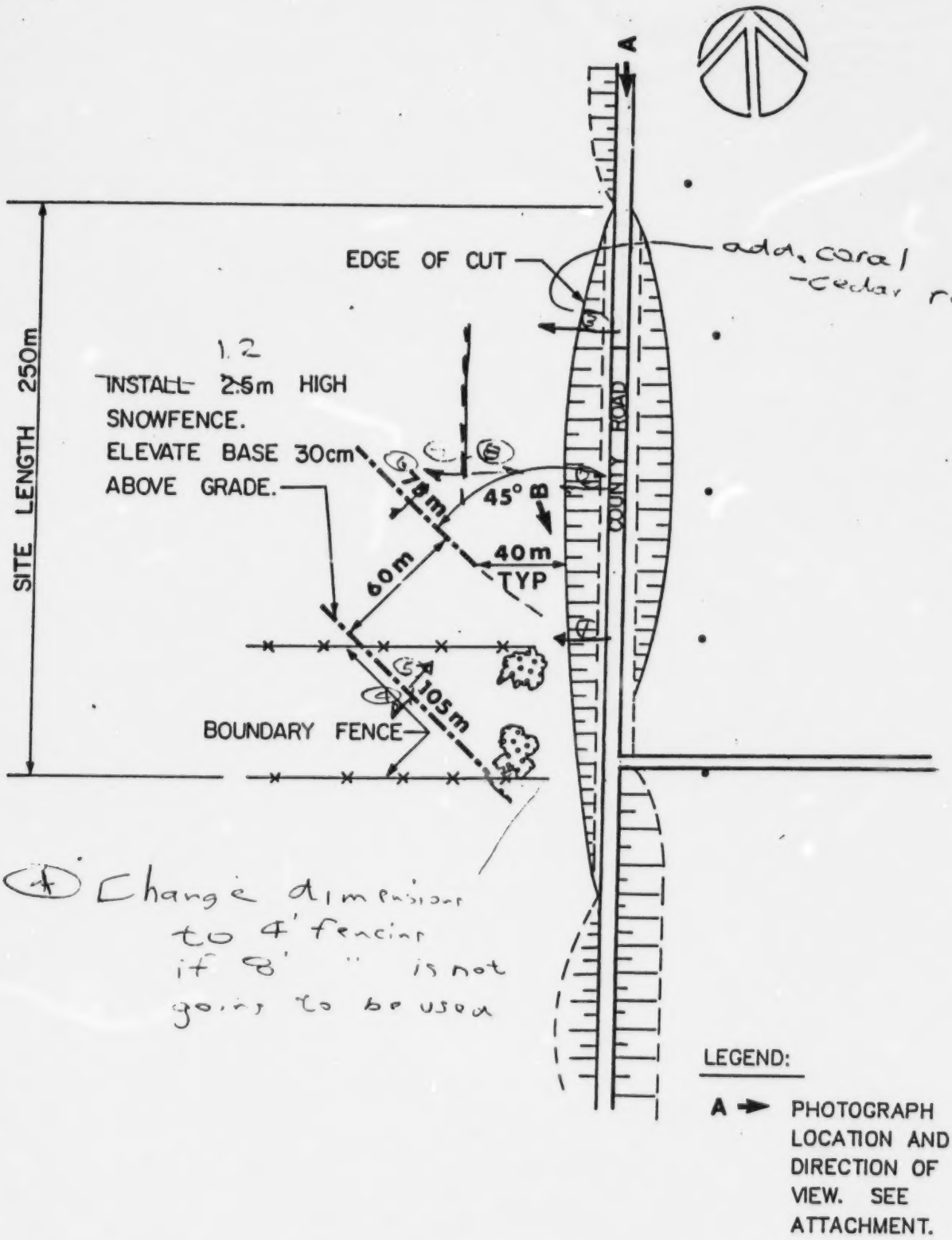
PLAN OF REFERENCE SITE

-INCLUDE DIRECTIONS TO FIND SITE FROM STUDY SITE.

-Same location as last year



④ Change dimension to 4' fencing if 8' " is not going to be used

RECOMMENDATIONS TO REDUCE SNOWDRIFTING
SITE 1-1 BRUCE COUNTY ROAD NO.1 PAISLEY

APPENDIX D

APPENDIX D-1

SITE SUMMARY

SITE NUMBER: 1-1

SITE NAME: Bruce County Road #1 (Brown's Cut)

SITE LOCATION: 2 km Southwest of Paisley

PROVINCE: Ontario

PRIMARY CONTACT: Eldon Yundt - County Engineer
County of Bruce - Walkerton, Ontario

DESCRIPTION OF PROBLEM:

The recent reconstruction of Bruce County Road #1 required that a 6m deep cut be created at this site. Recently snow accumulations of up to 5m deep have caused the closing of this road. Snowfencing has been used with limited success to resolve this problem. The County Engineer would like to proceed with an improved snowfence arrangement with consideration given to 2.5m high fences, double lift fences, angled fencing and/or multiple rows of fence.

PROBLEM IDENTIFICATION SITE VISIT:

On February 17, 1989, the problem identification site visit was conducted and field crews indicated the winter was less than typical. It was apparent that the prevailing winds were from the southwest to west (approximately 45° to road alignment) and the snowfence which was located upward of and parallel to the road was filled with snow. In addition, the study site had snow banks on the west side of the road which were up to 2.7m high. The reference site used was approximately 0.5 km south of the site on the same road. Here similar snow accumulations were recorded (see Figure D-1-1).

RECOMMENDED SOLUTION:

Weather data recorded at the nearby Paisley weather station supported an angled placement of 2.5m high snowfences as shown in Figure D-1-2.

SOLUTION ASSESSMENT SITE VISITS:

1) On March 3, 1988, a site visit was conducted to assess the recommended solution. It was learned from Mark Sprung, Paisley Patrol Foreman that they were not able to install 2.5m high fences. As a result, only 1.2m high fences were used but with the same spacing as a 2.5m fence. Therefore, very little difference in snow accumulation at the road was noted when compared to the previous winter (1986-87). In fact, when the snow profiles for both the Study Site and the Reference Site are compared (Figure

D-1-1) there were slightly higher accumulations recorded during the current winter. This is not indicative of the solution effectiveness but of a slightly more severe winter in 1987-88 (see Wiarton Meteorological Data, Appendix F).

2) On March 14, 1989, a second problem identification site visit was conducted and it was apparent that this winter was also less than typical (see Wiarton Meteorological Data, Appendix F). At the request of the Bruce County Engineer, Eldon Yundt, a 1.2m high snowfence arrangement had been developed and installed prior to winter (Figure D-1-3). These fences had not filled, however, there were accumulations adjacent to the road at both the reference and study sites. It would appear that northwesterly winds prevailed making the fence placement ineffective. However, these accumulations were not significant enough to cause problems.

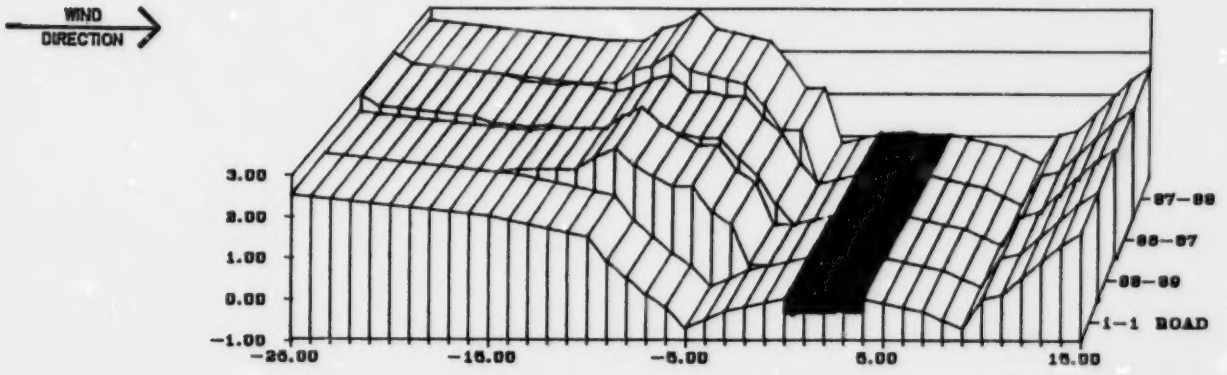
CONCLUSIONS:

Due to the less than typical winters at this site, it is difficult to make significant conclusions. However, it can be concluded that southwesterly winds prevail at the site and that snowfencing is the only practical solution since regrading the cut is too costly. Although not proven at this site, measurements made at sites in nearby Meaford would indicate that 2.5m high snowfences are more appropriate for this area of Ontario.

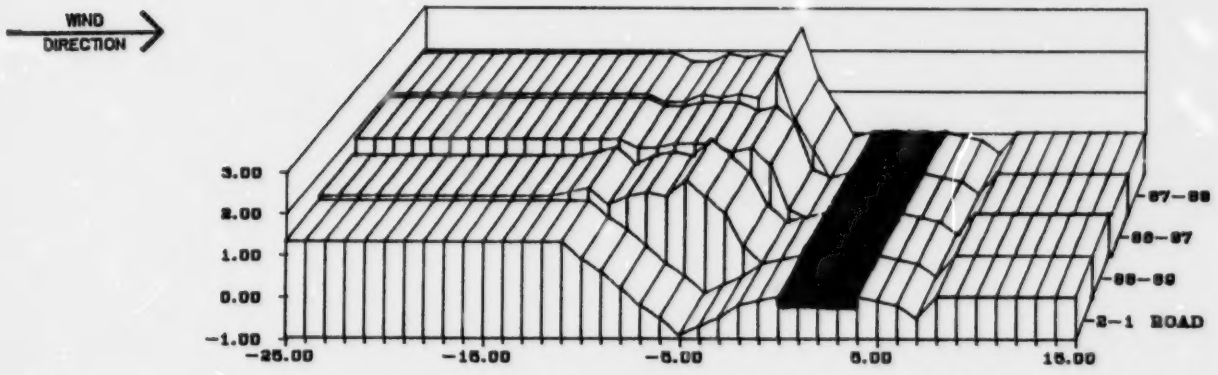
RECOMMENDATION:

It is recommended that future snowfence installations at this site include 2.5m high fences using the layout shown in Figure D-1-2.

PHOTOGRAPH OF STUDY SITE 1987–88 WINTER



TYPICAL CROSS SECTION AT STUDY SITE



TYPICAL CROSS SECTION AT REFERENCE SITE

FIGURE D–1–1

TYPICAL SNOW ACCUMULATIONS

SITE 1–1 BRUCE COUNTY ROAD NO.1, PAISLEY

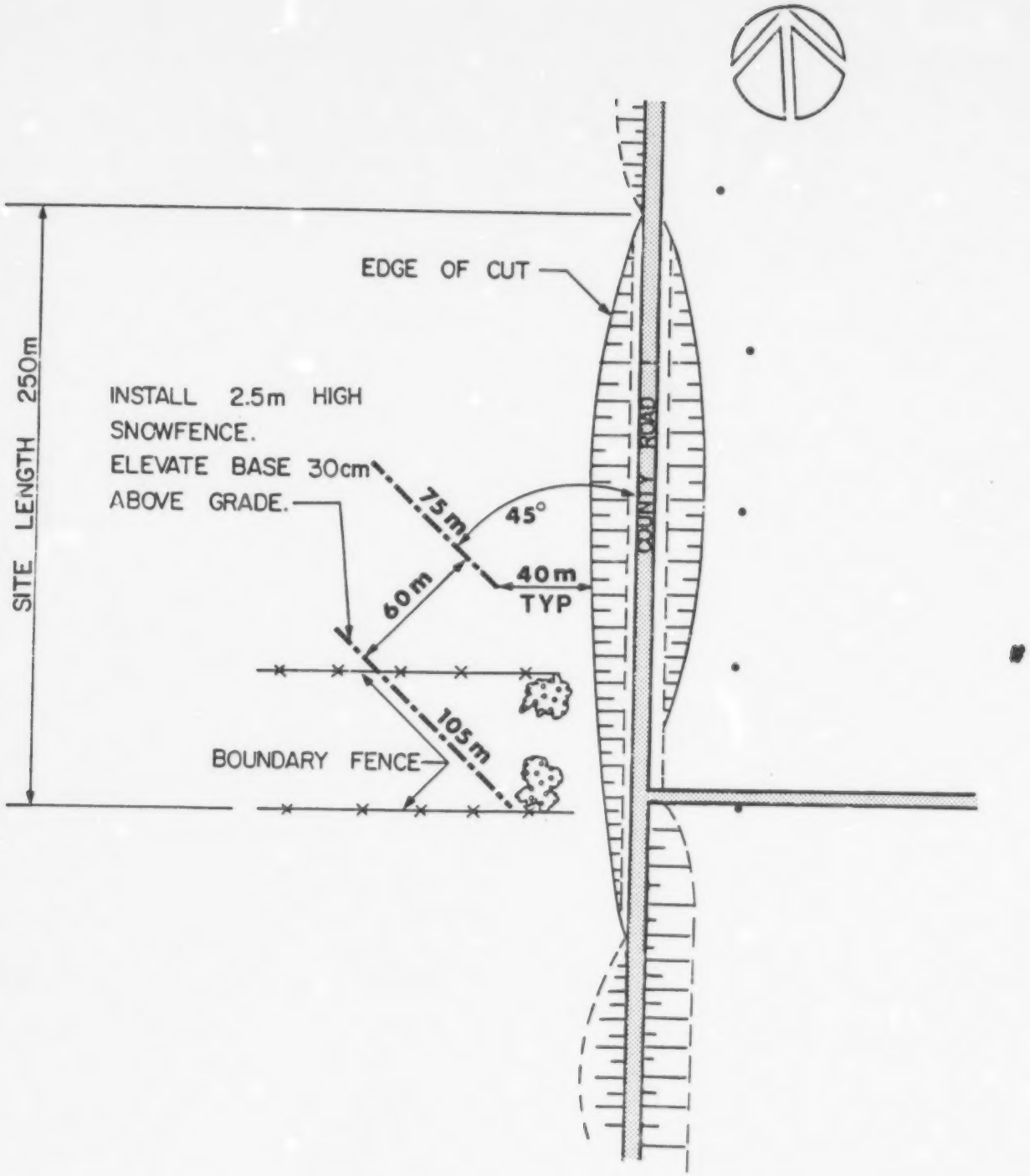


FIGURE D-1-2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1-1 BRUCE COUNTY ROAD NO.1, PAISLEY

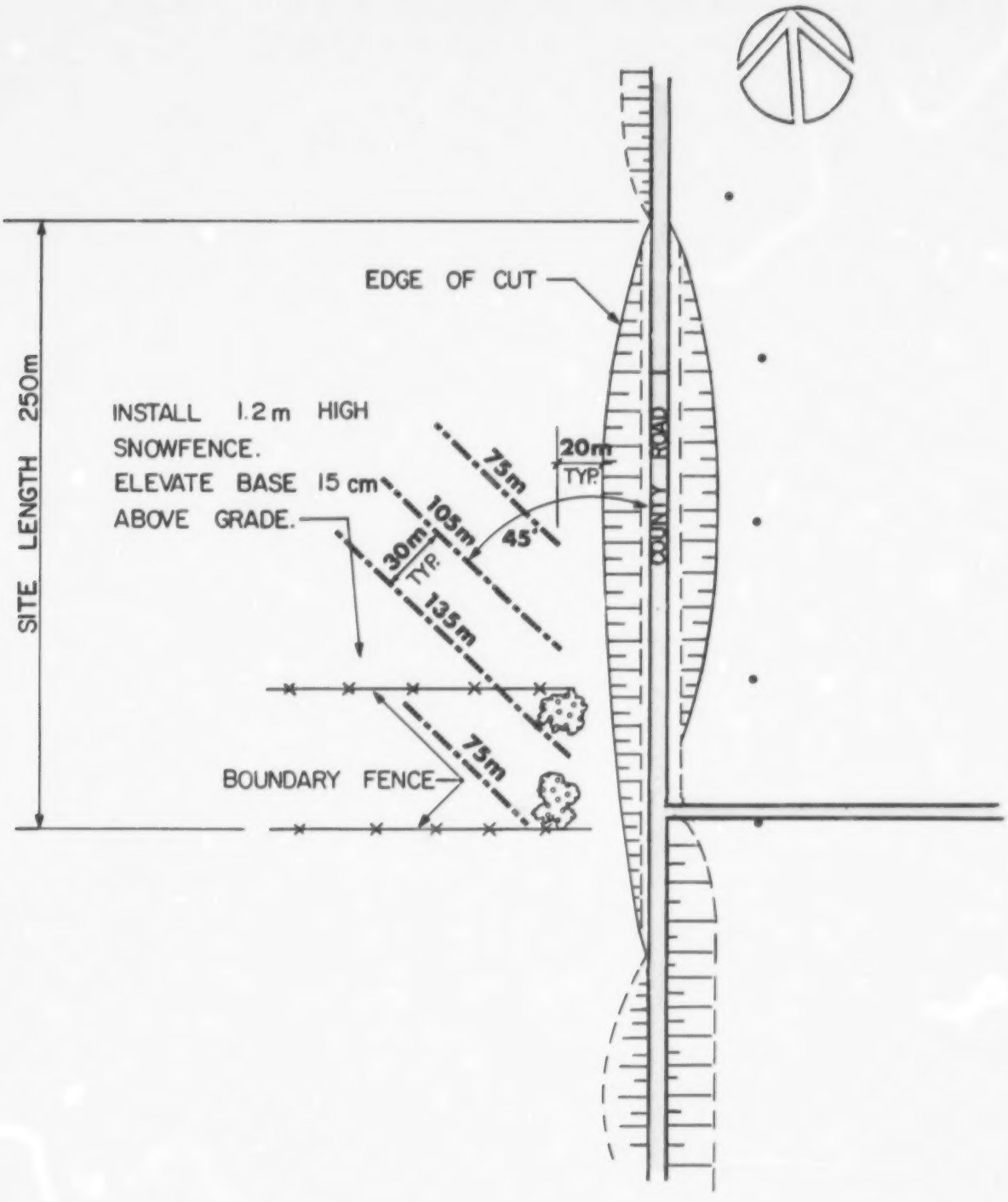


FIGURE D-1-3

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1-1 BRUCE COUNTY ROAD NO.1, PAISLEY

APPENDIX D-2

SITE SUMMARY

SITE NUMBER: 1-2

SITE NAME: Highway 24-Hornings Mills

SITE LOCATION: 1.5 km north of Redickville

PROVINCE: Ontario

PRIMARY CONTACTS: Joe E. Gruspier, Research Engineer
MTO, Downsview, Ontario

Max Perchanok, Research Engineer
MTO, Downsview, Ontario

DESCRIPTION OF PROBLEM:

The limited storage area for plowed snow in the ditches along this highway which is in a north-south orientation causes snow banks to form adjacent to the road. The prevailing west through northwest winds cause additional drifting on the road downwind of the snowbanks. MTO would like to consider 1.8m high snowfencing and/or permanent hedge rows to resolve this drifting problem.

PROBLEM IDENTIFICATION SITE VISIT:

On February 24, 1987, a problem identification site visit was conducted for this site. Snow accumulations of up to 2.2m deep were recorded adjacent to the road (Figure D-2-1). Highway maintenance crews indicate that on a typical winter, these banks are as high as 3 - 4 metres.

RECOMMENDED SOLUTION:

Based on meteorological data collected at Mount Forest and Wiarton, Ontario, a double row of 1.8m high snowfence was recommended as shown in Figure D-2-2.

SOLUTION ASSESSMENT SITE VISITS:

1) On January 28, 1988, a site visit was conducted to assess the effectiveness of the installed solutions. Our observations indicated that the double row of 1.8m high fences had been installed. However, the lateral bracing had failed permitting the wind to blow the fence over. The bracing used involved an angled brace wired to the downwind side of the post. This bracing was adequate for westerly winds. However, easterly winds occurred which separated the connection, causing the failure. As a result of the failure and a less than typical winter, snowdrift measurements were not made.

2) On February 7 and 19, 1989, additional site visits were made to observe the performance of the recommended solution at this site. This time the fence was braced with wires fastened to the top of the fence post and to a metal anchor post driven into the ground on both sides of the fence. Although the winter was less than typical, the fences accumulated up to 1.8m of snow in the westerly fence and 1.0m in the easterly (see Figure D-2-1).

Similar to the previous year, snow depth measurements were not made at the road, due to the non typical winter.

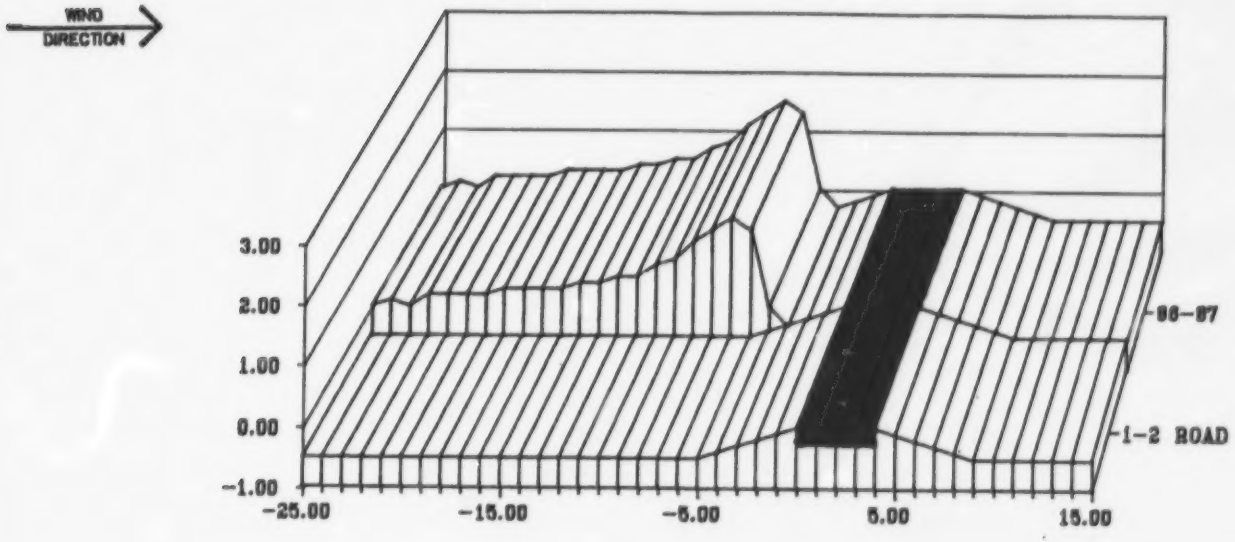
CONCLUSIONS:

Although snowdrifting conditions for a typical winter were not observed at this site, it would appear that the parallel fencing arrangement tested could be adequate to control drifting. If local property owners could be encouraged to participate, the fences could be replaced by a permanent solution involving the use of 5m high coniferous trees closely planted a minimum distance of 50m upwind of the road.

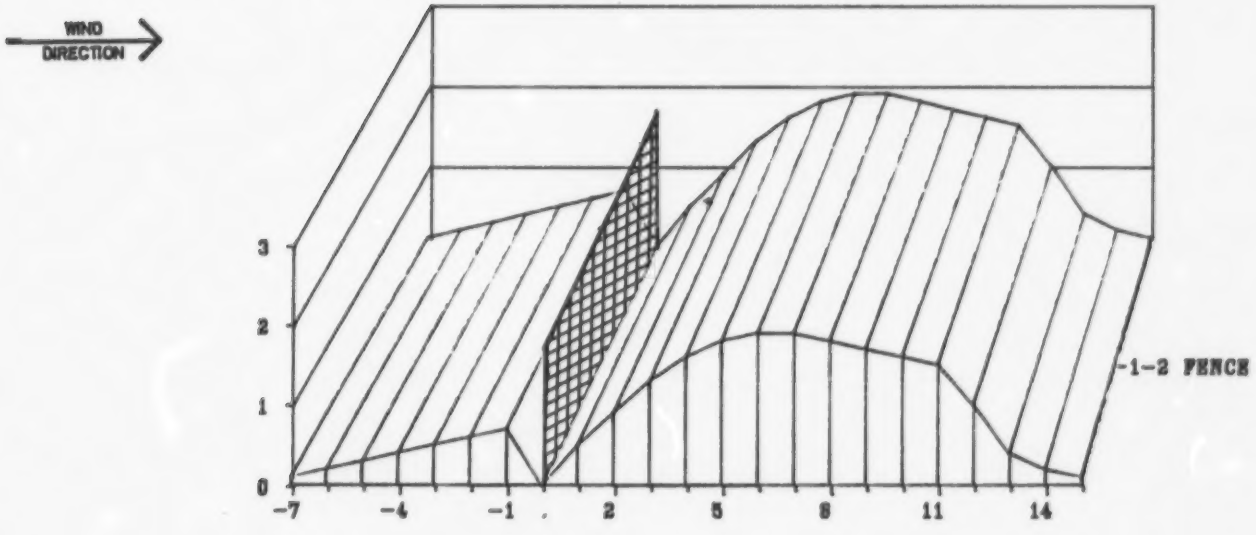
In addition, it can be concluded that 1.8m high snowfences need to be laterally braced on both sides of the fence, in a manner similar to the method used in the 1988-89 winter.

RECOMMENDATIONS:

Future snow control devices at this site should include two rows of 1.8m high snowfences, with posts spaced approximately 3m apart and alternate posts laterally braced on both sides of the fence.



TYPICAL CROSS SECTION AT STUDY SITE (1986-87)



CROSS SECTION OF 1.8m FENCE (1988-89)

FIGURE D-2-1

TYPICAL SNOW ACCUMULATIONS

SITE 1-2, HIGHWAY 24, HORNINGS MILLS

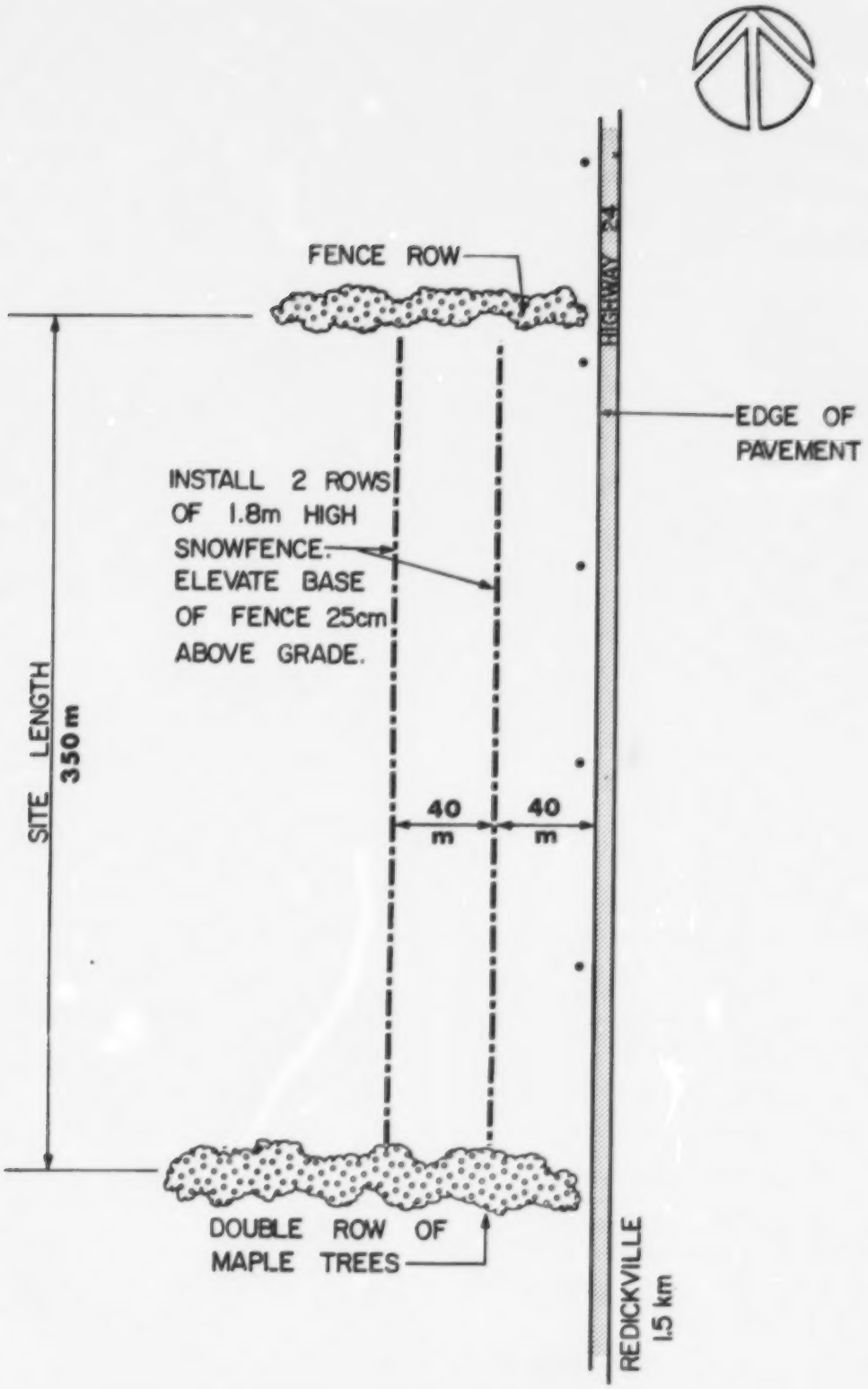

FENCE ROW
HIGHWAY 24
EDGE OF PAVEMENT
INSTALL 2 ROWS OF 1.8m HIGH SNOWFENCE. ELEVATE BASE OF FENCE 25cm ABOVE GRADE.
SITE LENGTH 350 m
40 m
40 m
DOUBLE ROW OF MAPLE TREES
REDICKVILLE 1.5 km

FIGURE D-2-2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1-2, HIGHWAY 24, HORNING'S MILLS

APPENDIX D-3

SITE SUMMARY

SITE NUMBER: 1-3

SITE NAME: Highway 91 - Stayner

SITE LOCATION: 2.1 km west of MTO Stayner Yard

PROVINCE: Ontario

PRIMARY CONTACTS: Joe E. Gruspier - Research Engineer
MTO, Downsview, Ontario

Max Perchanok - Research Engineer
MTO, Downsview, Ontario

DESCRIPTION OF PROBLEM:

The cut section at this site causes snowdrifting on the north side of the road which is oriented in an east-west direction. Currently MTO are using snowfencing with limited success to control this problem. Improved installation methods and a different fence layout will reduce the accumulations adjacent to the highway. The adjacent property owner, Mr. Ross Beattie has shown interest in participating in an alternate solution to this problem. He would be willing to leave a few rows of corn adjacent to the highway in place of the snowfence.

PROBLEM IDENTIFICATION SITE VISIT:

On February 24, 1987, a problem identification site visit was conducted for this site. This winter was not typical from a snowfall point of view but the winds occurred from the northwest, which are typical. The resultant snow accumulations at the site are shown in Figure D-3-1. Since the adjacent property owner usually plants corn in this field, it was agreed that he would be contacted to discuss the possibility of leaving a few rows of corn (unharvested) to act as a snowfence. A future meeting with the owner proved encouraging as he was in favour of cooperating, however, the crop rotation used resulted in another type of crop being planted. As a result, snowfencing had to be used.

RECOMMENDED SOLUTION:

The angled fencing arrangement shown in Figure D-3-2 was developed to control snowdrifting in the cut.

SOLUTION ASSESSMENT SITE VISITS:

1) On March 2, 1988, a solution assessment site visit was conducted during which it was noted that only one row of snowfence (the most westerly fence in Figure D-2-2) was installed. The snow accumulations measured at the road show a reduction in accumulation adjacent to the cut compared to the previous winter (Figure D-3-1). However, this improvement is largely due to a light winter of snowfall and drifting.

   The lateral bracing used for this fence involved the use of wires placed at both sides of the fence every third post, which were spaced every 3 - 5m (see Figure D-3-1). Although the posts supported by the braces remained reasonably upright, the two intermediate posts bent considerably more.

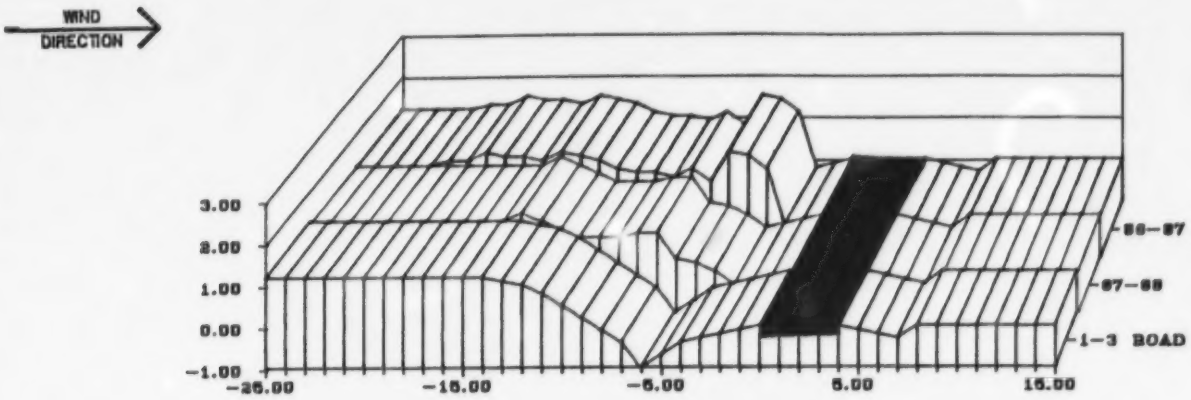
2) On February 19, 1989, another site visit was conducted to observe the 1988-89 fencing installation at this site. This time the 2 most westerly rows of fencing (see Figure D-3-2) were installed with a revised bracing method. Once again, very little snowfall was recorded in this area and as a result very little snow accumulation was observed at both fences and adjacent to the road. This year the fence posts were installed 3m apart with lateral bracing every fourth post. However, the guy wires were attached to the top of the anchor post which permitted the fence to lean in the direction of the wind (Figure D-3-1).

CONCLUSIONS:

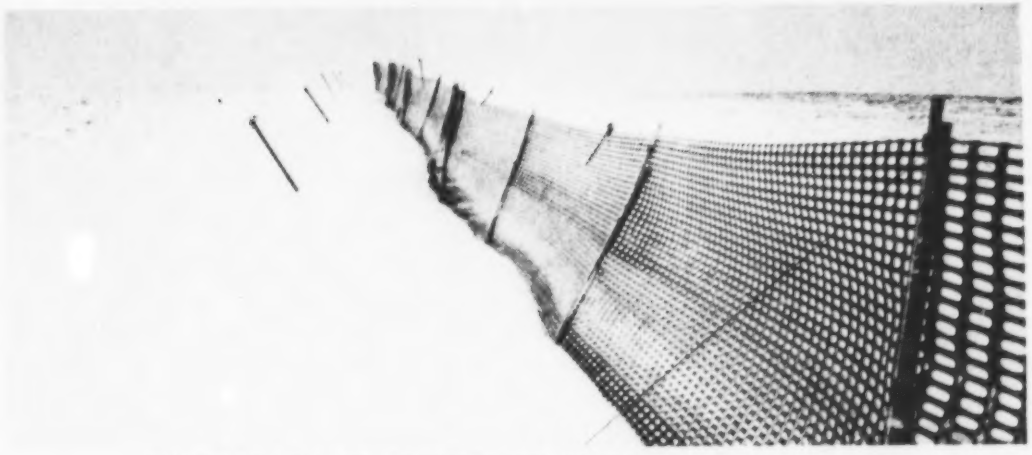
The less than typical winters at this site have made it difficult to make any firm conclusions about the fence placement other than the orientations of the fences are correct but conclusions about the lateral bracing can be made. From observations made lateral bracing is required on the 1.8m high fences used. However, they need to be more frequent and the connections to the anchors and posts should be changed.

RECOMMENDATIONS:

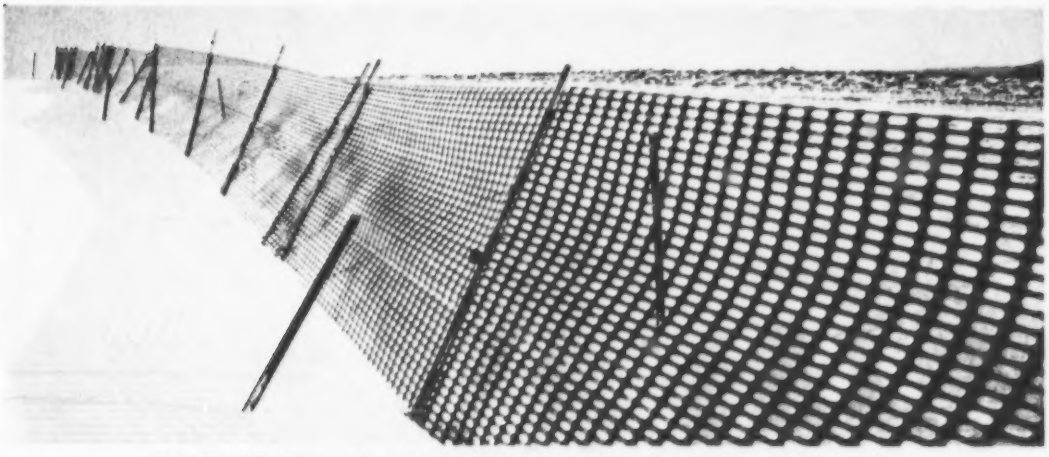
Continued use of the fence layout shown in Figure D-3-2 is recommended until it experiences a typical winter, at such time its effectiveness can be determined. The fence should be installed using T-bar posts spacing 3m apart and laterally braced every other post using the anchoring details shown in the companion manual of this report.



TYPICAL CROSS SECTION AT STUDY SITE



PHOTOGRAPH OF SNOWFENCE INSTALLATION 1987-88



PHOTOGRAPH OF SNOWFENCE INSTALLATION 1988-89

FIGURE D-3-1

TYPICAL SNOW ACCUMULATIONS

SITE 1-3, HIGHWAY 91, WEST OF STAYNER

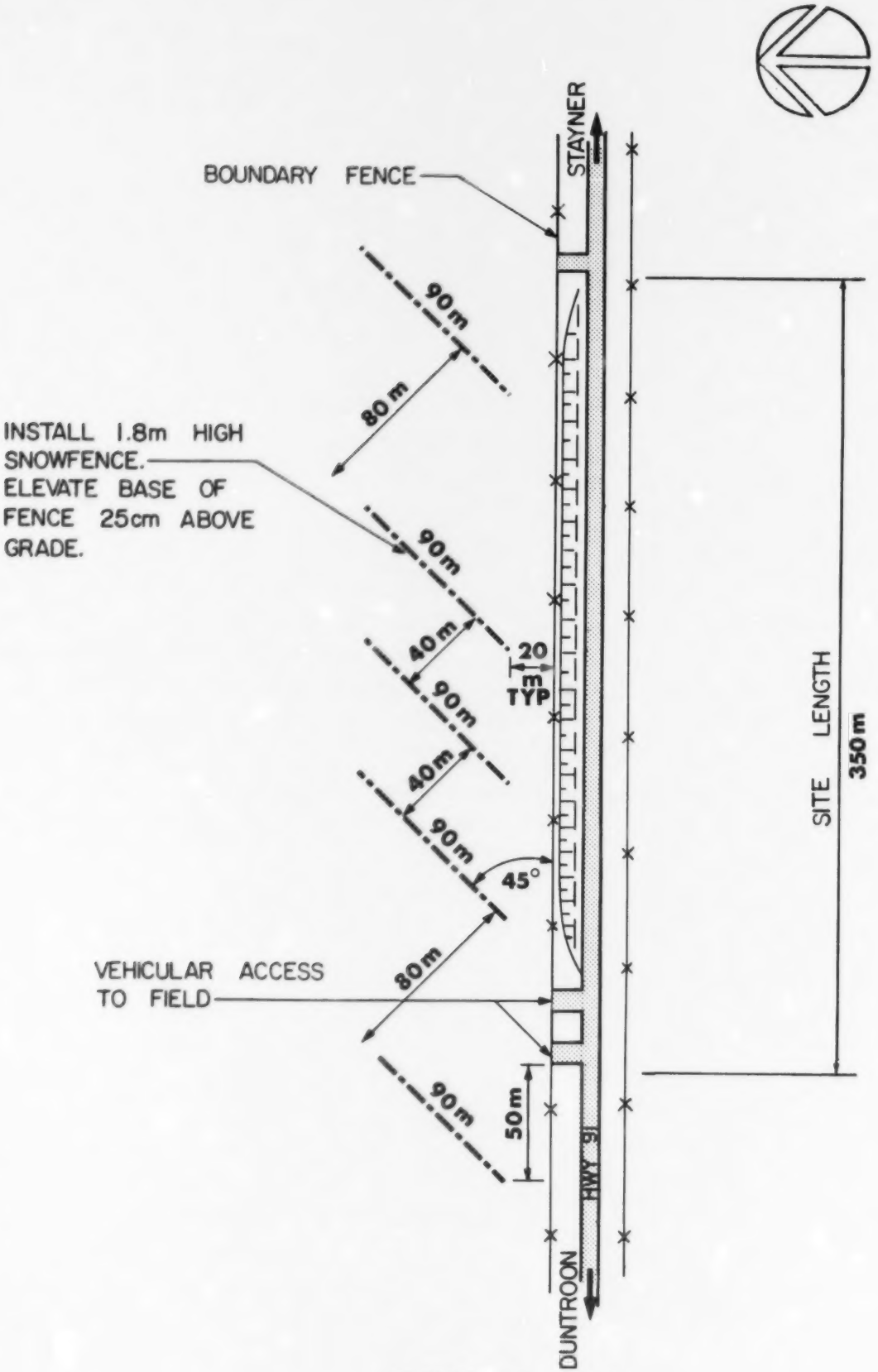


FIGURE D-3-2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1-3, HIGHWAY 91, WEST OF STAYNER

APPENDIX D-4

SITE SUMMARY

SITE NUMBER: 1-4

SITE NAME: Highway 100

SITE LOCATION: South of Hamilton Road, London

PROVINCE: Ontario

PRIMARY CONTACTS: Joe E. Gruspier, Research Engineer
MTO, Downsview, Ontario

Max Perchanok, Research Engineer
MTO, Downsview, Ontario

DESCRIPTION OF PROBLEM:

The cut located on the west side of Highway 100 at this site causes snow accumulations which have closed this road in the past. The regrading of the backslope, snowfencing, and/or plant material could resolve this problem.

PROBLEM IDENTIFICATION SITE VISIT:

On February 20, 1987, a site visit was conducted to assess the problem condition. Due to the minimal snow accumulations at the site the problem condition was not visible. However, it was agreed to proceed with the development of a snowfence arrangement for this location.

RECOMMENDED SOLUTION:

From meteorological data recorded at London Airport and the local site conditions, a 1.8m high snowfence was recommended for installation along an existing ridge in the field approximately 50m west of the west boundary fence (Figure D-4-1).

SOLUTION ASSESSMENT SITE VISITS:

1) On February 4, 1988, a site visit was conducted and it was observed that a 1.2m high snowfence was installed as located on Figure D-4-1. Due to an absence of snow, measurements could not be made.

2) On March 15, 1989, a site visit was conducted. Similar to the previous winter, only 1.2m high fencing was used and the absence of snow did not permit any measurements.

CONCLUSIONS:

Due to the lack of snow at this site during all three study years, a lack of data does not permit any conclusions to be drawn about the effectiveness of the solution.

RECOMMENDATIONS:

Further use of the solution shown in Figure D-4-1 is recommended until it experiences a typical winter. At that time, MTO should assess the effectiveness of the solution and ultimately its continued use.

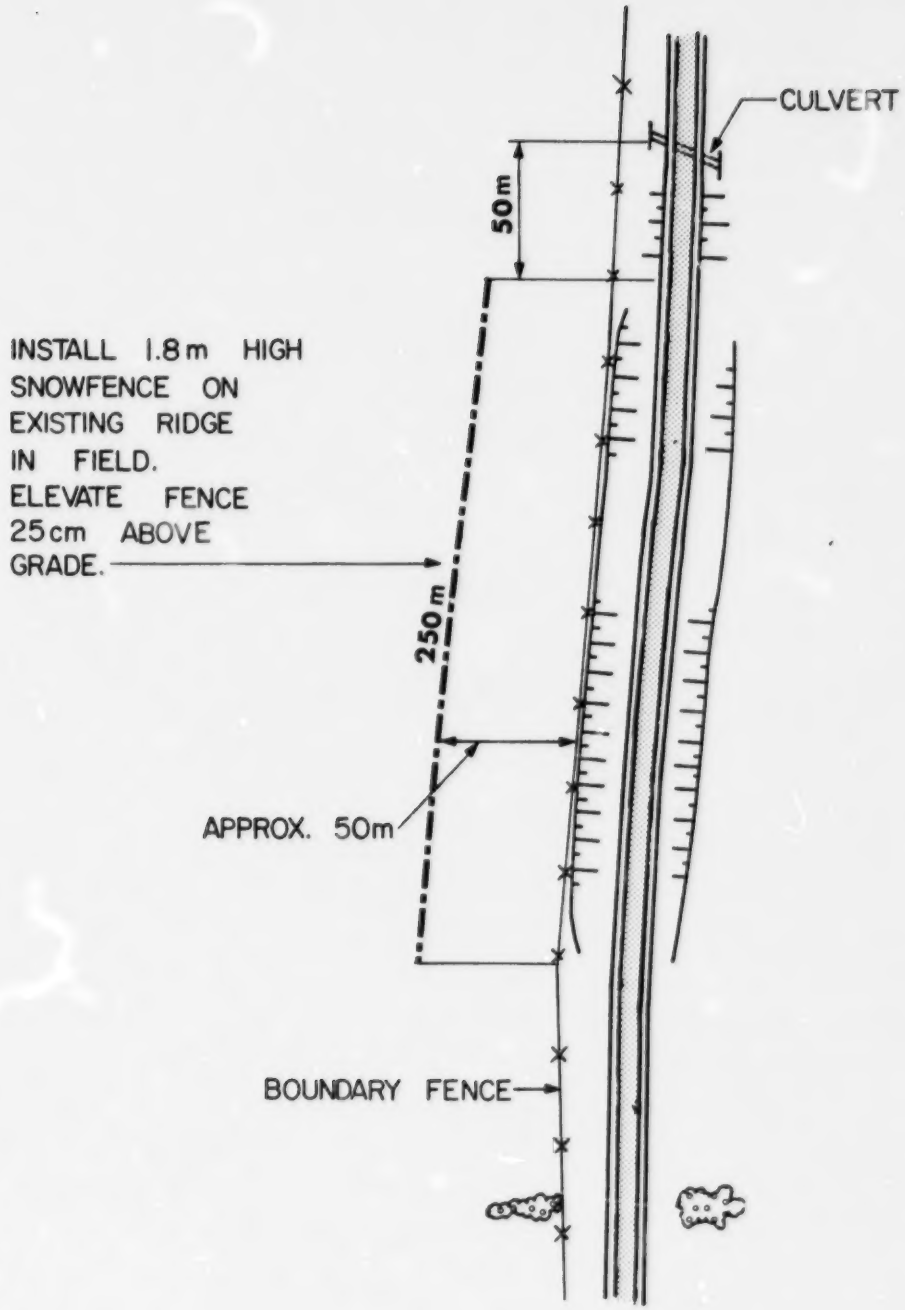


FIGURE D–4–1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1–4 HWY 100 SOUTH OF HAMILTON ROAD, LONDON

APPENDIX D-5

SITE SUMMARY

SITE NUMBER: 1-5

SITE NAME: Highway 100

SITE LOCATION: South of Site 1-4, London

PROVINCE: Ontario

PRIMARY CONTACTS: Joe E. Gruspier, Research Engineer
MTO, Downsview, Ontario

Max Perchanok, Research Engineer
MTO, Downsview, Ontario

DESCRIPTION OF PROBLEM:

Three small cuts on the west side of Highway 100 initiate snowdrifts which progress onto the highway. The removal of the mounds that form these cuts is possible since they are located within the MTO right-of-way.

PROBLEM IDENTIFICATION SITE VISIT:

On February 20, 1987, a site visit was conducted to assess the problem condition. A lack of snow did not permit the observation of the problem. However, from field crew descriptions of the problem during previous winters, it was decided that regrading would be considered as the solution.

RECOMMENDED SOLUTION:

The three cuts shown in Figure D-5-1 should be regraded as shown in Section P-P in Figure D-5-2.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 4, 1988, a site visit was conducted and it was observed that approximately half of the grading had been completed. Cuts #1 and #2 were virtually complete but Cut #3 had not been started (a later report from MTO indicated that site would was completed on May 26, 1988). A lack of snow at the site did not permit measurements to be made.

2) On March 15, 1989 another site visit was conducted. It was observed that the site work was complete but a lack of snow did not permit measurements to be made.

CONCLUSIONS:

The lack of snow at this site during the 3 study years does not permit conclusions to be made about the effectiveness of the solution.

RECOMMENDATIONS:

MTO should monitor the effectiveness of this solution and that the appropriate steps to improve the solution be taken if it does not prove to be effective.

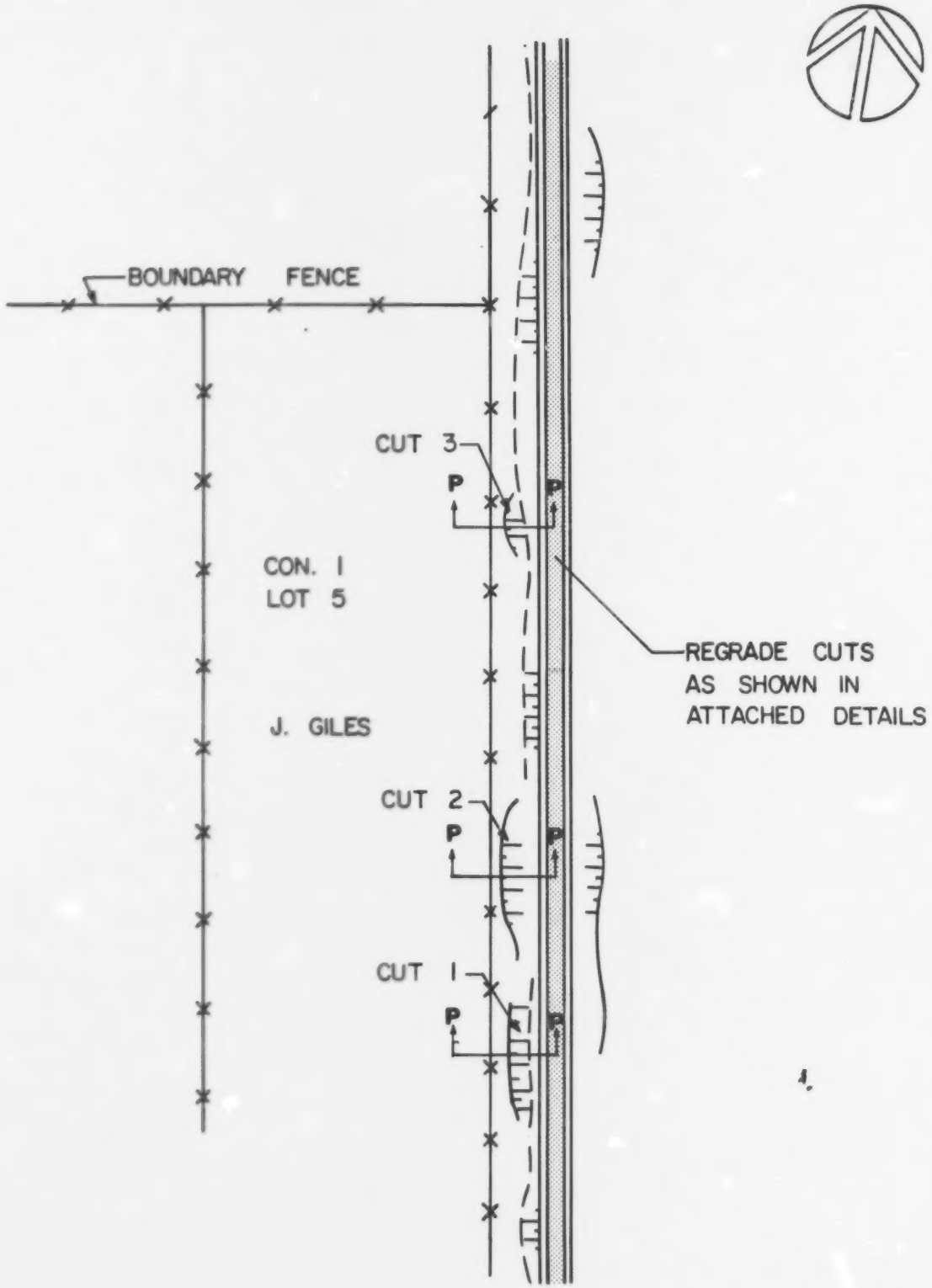
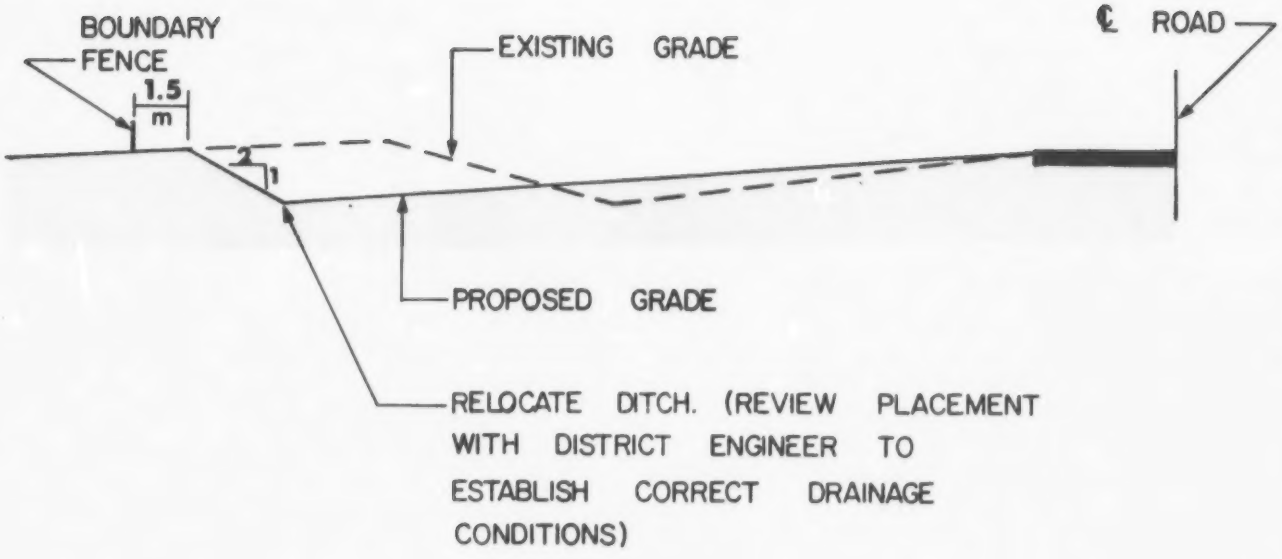


FIGURE D-5-1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1-5, HWY 100 NORTH OF HWY 401, LONDON



SECTION P-P

FIGURE D-5-2
DETAILS OF RECOMMENDED SOLUTION
SITE 1-5, HWY 100 NORTH OF HWY 401, LONDON

APPENDIX D-6

SITE SUMMARY

SITE NUMBER: 1-6

SITE NAME: Wellington County Road 32

SITE LOCATION: South of Highway 7 - Guelph

PROVINCE: Ontario

PRIMARY CONTACT: Bill Eggert - Assistant to County Engineer
County of Wellington, Guelph

DESCRIPTION OF PROBLEM:

The road at this site is oriented in a NNW-SSE direction. The westerly winds which blow over the open fields to the west transport the snow towards the cut section and plowed snowbanks adjacent to the west side of the road. This site was used as an experimental site to develop new snowfence installation methods. The proximity of the site to our office (RWDI) permitted regular inspections of the performance of the fencing.

PROBLEM IDENTIFICATION SITE VISIT:

On February 23, 1987, a site visit was conducted to record the problem conditions. Snowbanks up to 1.7m deep were recorded along the west side of the road indicating a prevailing westerly wind. From Appendix F the weather conditions recorded at nearby Waterloo Wellington Airport indicate that this winter was less than typical.

RECOMMENDED SOLUTION:

For the purpose of this study, 2 rows of 1.2m high snowfencing were installed with varying bottom details (see Figure D-6-1).

SOLUTION ASSESSMENT SITE VISITS:

1) During the 1987-88 winter, numerous visits were made to the site to observe the fence installation. However, the lack of snow resulted in only one useable set of information. The graphs shown in Figure D-6-2 illustrate the different snowdrift cross-sections recorded at each section of fence.

2) The property owner was not cooperative in permitting the installation of this fence during the 1988-89 winter. However, a similar location on County Road 32 (Site 1-29) was chosen and a similar fencing arrangement was installed. However, the lack of snow during the 1988-89 winter did not permit any measurements to be made.

CONCLUSIONS:

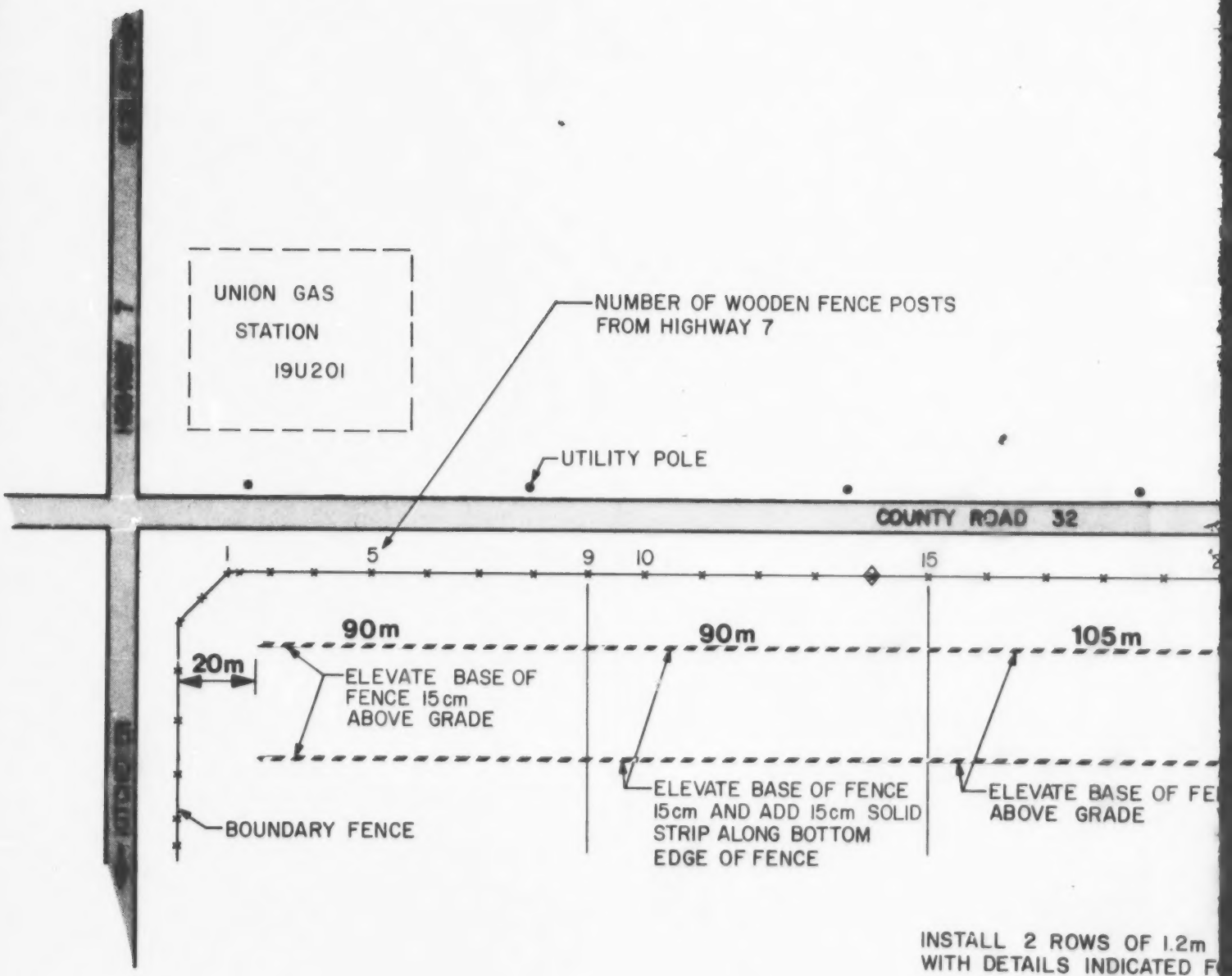
The installation of elevated fences are difficult particularly when end bracing is not used, as was the case at this site. Since the fence sagged between posts, stakes were inserted midway between posts to support the fence.

The smaller gap size (15cm) was not sufficient to keep the fence from plugging. However, when the solid strip was added for a 15cm gap, the wind speed increased at the base of the fence which kept the gap clear of snow. The accelerated winds also caused the snow to accumulate further from the fence (see Figure D-6-2).

The larger 30cm and 45cm gaps also performed well in keeping the base of the fence scoured away from snow. However, the lack of snow at this site during the study period was not adequate to draw any definite conclusions.

RECOMMENDATIONS:

The future use of a double row 1.2m high snowfence is recommended. A bottom gap of up to 30cm is recommended to prolong the effectiveness of the fence. In order to maintain this gap, end bracing is also recommended to ensure that the tension applied to the fence during construction is maintained throughout the winter. It is also recommended that this bracing the included at intermediate points along the fence, approximately every 40m.


UNION GAS
STATION
19U201
NUMBER OF WOODEN FENCE POSTS
FROM HIGHWAY 7
UTILITY POLE
COUNTY ROAD 32
1
5
9
10
15
90m
90m
105m
20m
ELEVATE BASE OF
FENCE 15cm
ABOVE GRADE
BOUNDARY FENCE
ELEVATE BASE OF FENCE
15cm AND ADD 15cm SOLID
STRIP ALONG BOTTOM
EDGE OF FENCE
ELEVATE BASE OF FE
ABOVE GRADE
INSTALL 2 ROWS OF 1.2m
WITH DETAILS INDICATED F

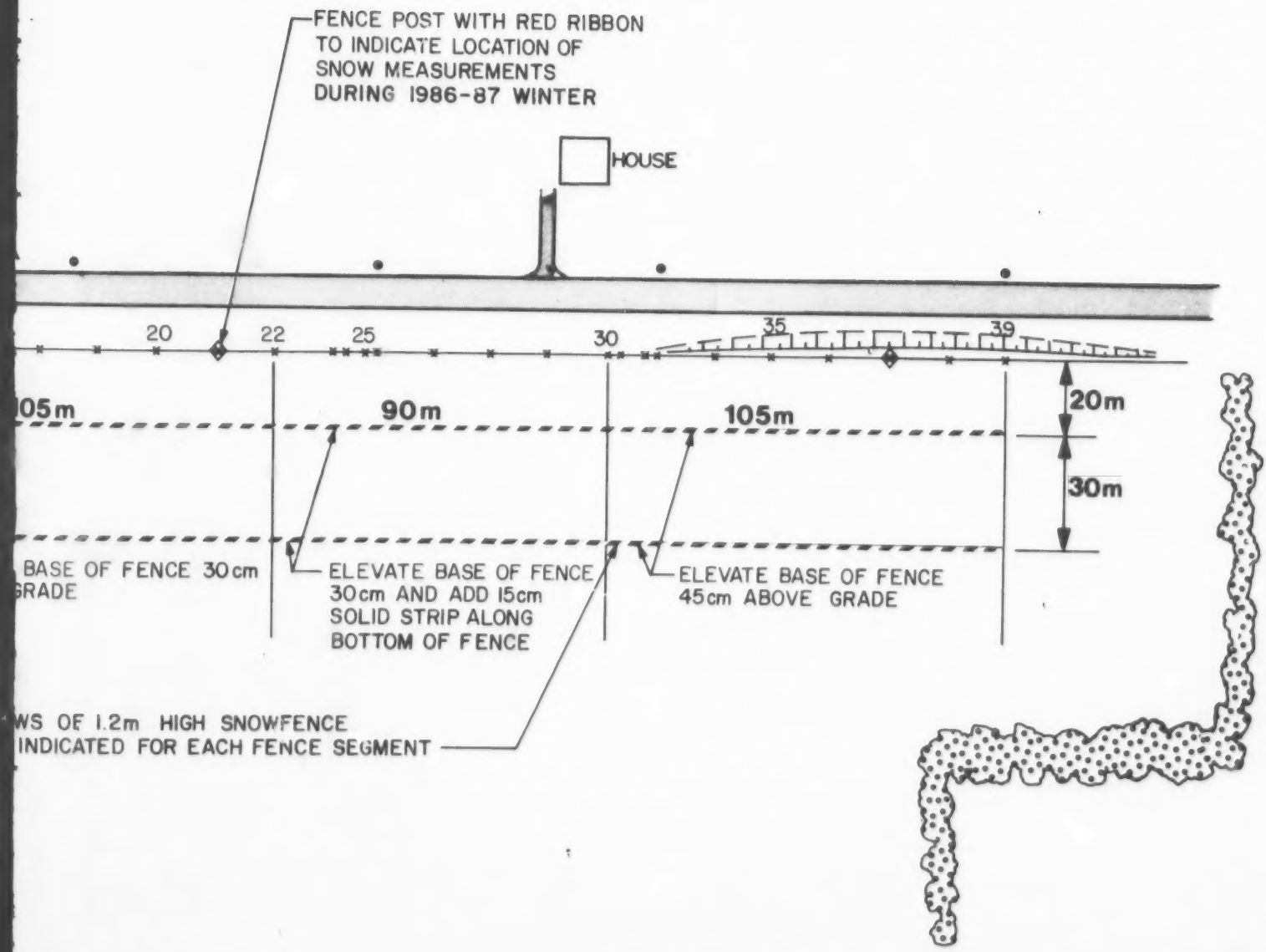
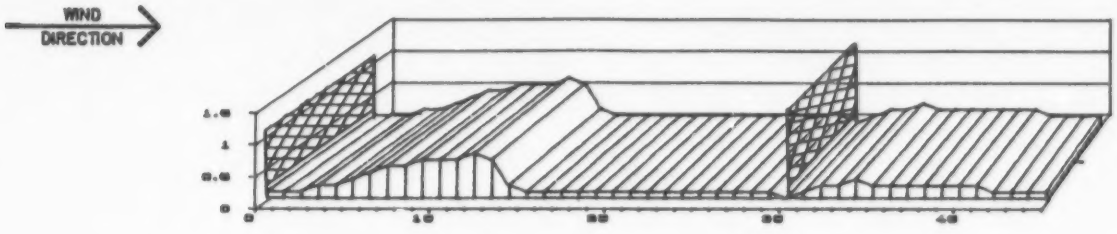


FIGURE D-6-1

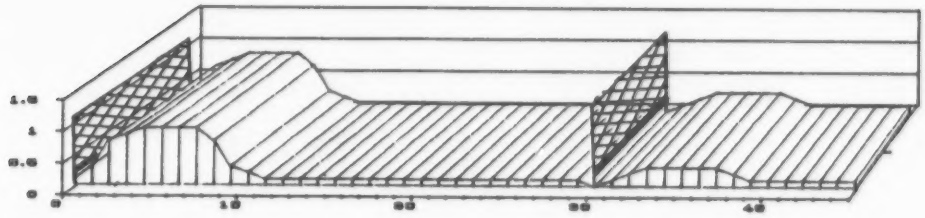
RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1-6 WELLINGTON COUNTY ROAD 32 AT HIGHWAY 7, GUELPH

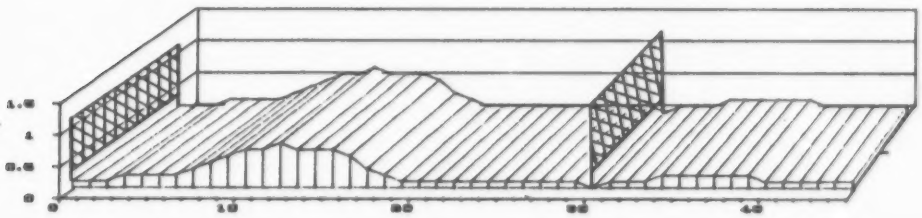
RWDI



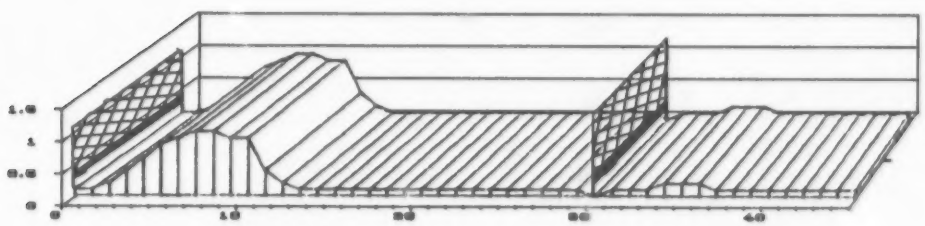
1.2m HIGH FENCE – ELEVATED 15cm



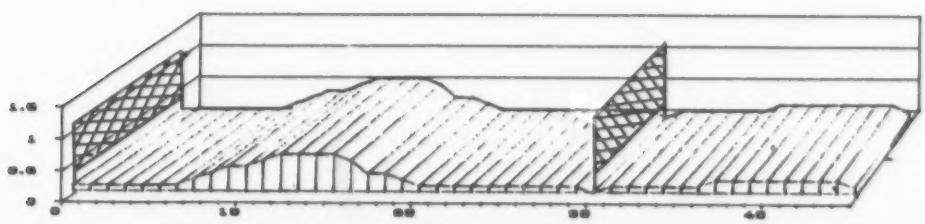
1.2m HIGH FENCE – ELEVATED 15cm WITH 15cm SOLID STRIP



1.2m HIGH FENCE – ELEVATED 30cm



1.2m HIGH FENCE – ELEVATED 30cm WITH SOLID STRIP



1.2m HIGH FENCE – ELEVATED 45 cm

FIGURE D–6–2

TYPICAL SNOW ACCUMULATIONS

SITE 1–6 WELLINGTON COUNTY ROAD 32 AT HIGHWAY 7, GUELPH

APPENDIX D-7

SITE SUMMARY

SITE NUMBER: 1-8

SITE NAME: 'Crumlin Side Road

SITE LOCATION: Between Oxford and Dundas Streets, London

PROVINCE: Ontario

PRIMARY CONTACT: Jim Hobbs - Maintenance Engineer
City of London

DESCRIPTION OF PROBLEM:

The limited storage area for plowed snow along this road which runs in a north-south direction causes snow banks to form along the west side of the road. The prevailing westerly winds deposit snow in the calm air region formed by the snowbank. The City of London would like snowfencing and/or landscaping considered as the solution at this site.

PROBLEM IDENTIFICATION SITE VISIT:

On February 20, 1987, a site visit was conducted to assess the problem conditions. The lack of snow at the site did not permit measurements to be made. However, it was decided to proceed with this site based on discussions about the problem conditions during previous winters with field crew members.

RECOMMENDED SOLUTION:

Since the upwind area was planted with corn, it was decided to approach the property owner about leaving 6 to 12 rows of corn in the field in place of installing snowfences (see Figure D-7-1). However, the owner would not cooperate so a snowfence arrangement was developed, as shown in Figure D-7-2.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 4, 1988, a site visit was conducted to assess the effectiveness of the remedial measures. It was observed that plastic crowd control fence material was used. Since this material is approximately 10% solid, it offers very little resistance to the wind, resulting in very small snow accumulations at the fence. This problem coupled with a less than typical winter produced insignificant snow accumulations. Therefore, snow depth measurements were not made.

2) On March 15, 1989, another site visit was conducted. During the visit, it was noted that 50% solid wood slat fences were installed as shown in Figure D-7-2.

A lack of snow during the winter did not permit measurements to be taken.

CONCLUSIONS:

The lack of typical winter conditions do not permit conclusions to be drawn about the effectiveness of the solutions.

RECOMMENDATIONS:

It is recommended that the snowfencing detailed in Figure D-7-2 be installed in the future. Once a typical winter occurs then the City of London can assess its effectiveness and decide upon its continued use.

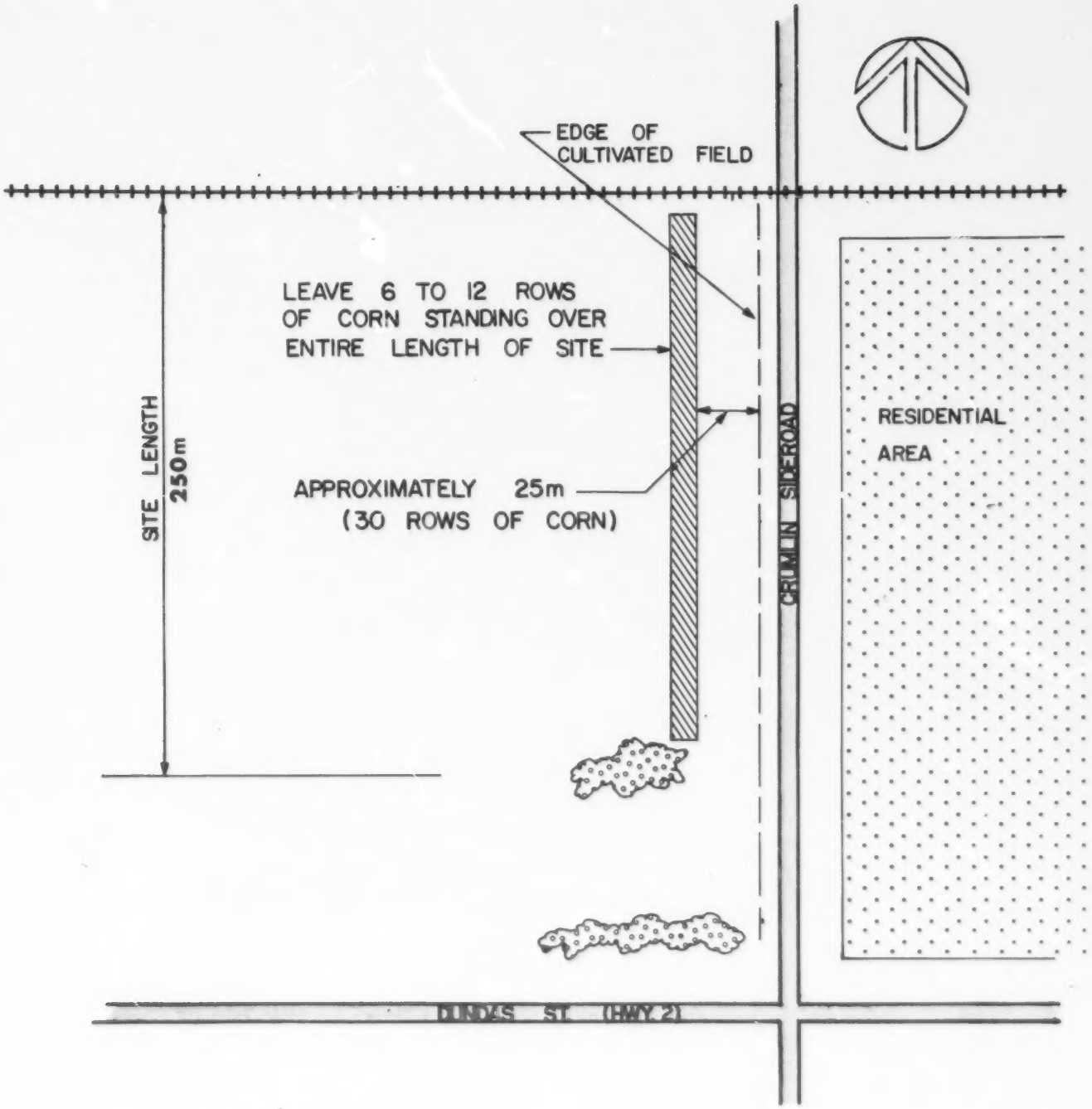


FIGURE D--7-1

RECOMMENDATION TO REDUCE SNOWDRIFTING

SITE 1-8 CRUMLIN SIDEROAD, LONDON

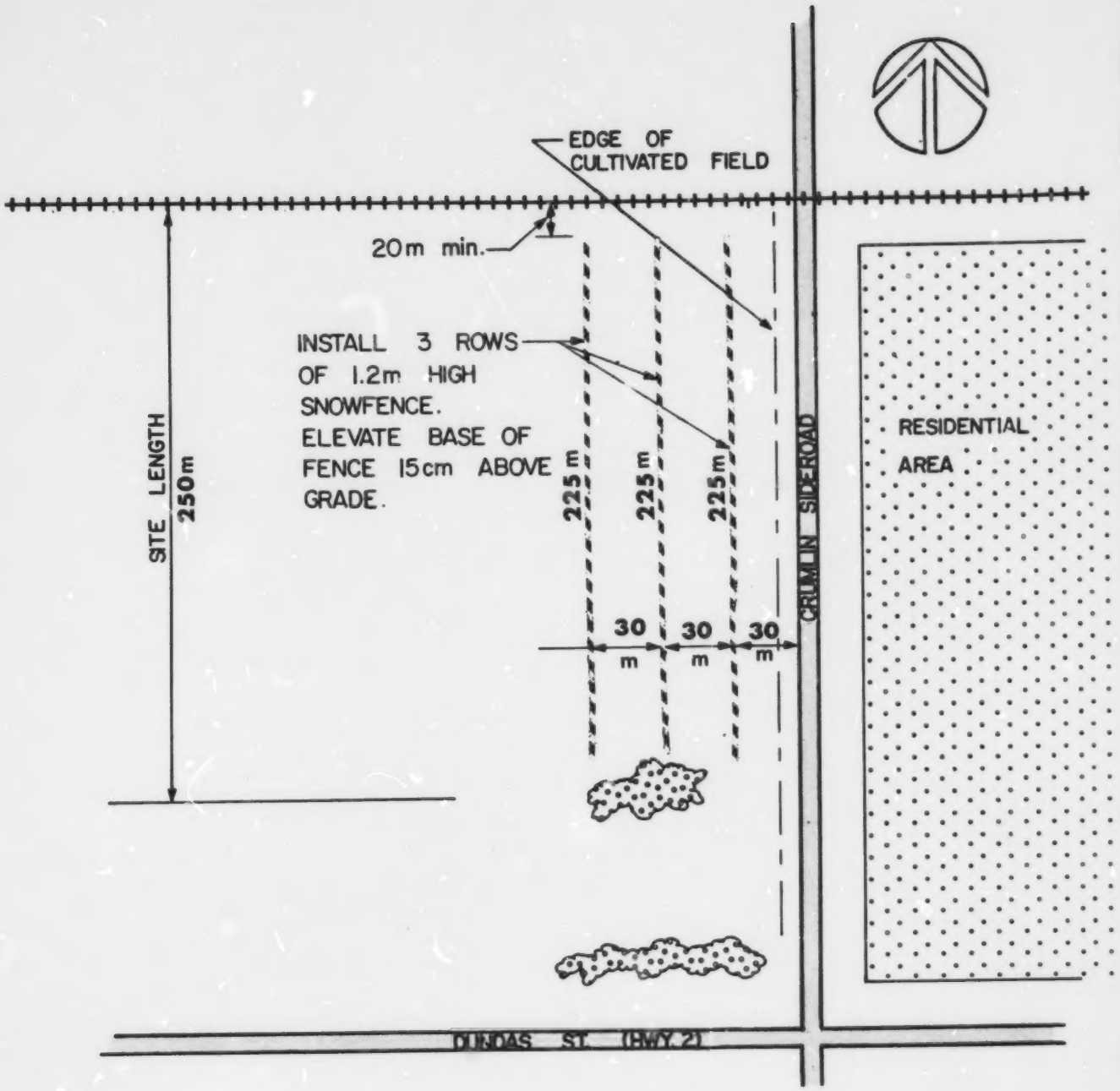


FIGURE D-7-2

ALTERNATE RECOMMENDATION TO REDUCE SNOWDRIFTING

SITE 1-8 CRUMLIN SIDEROAD, LONDON

APPENDIX D-8

SITE SUMMARY

SITE NUMBER: 1-9

SITE NAME: Jalna Blvd.

SITE LOCATION: South of Bradley Avenue, London

PROVINCE: Ontario

PRIMARY CONTACT: Jim Hobbs, Maintenance Engineer
City of London

DESCRIPTION OF PROBLEM:

This site is located in a suburban area at the east end of a park. The apartment buildings to the north and the houses to the south direct the snow laden westerly winds towards the site. Since there is not a ditch along the street, plowed snowbanks are formed adjacent to the west side of Jalna Blvd. These snowbanks cause additional snow accumulations which eventually have to be hauled away.

PROBLEM IDENTIFICATION SITE VISIT:

On February 20, 1987, a site visit was conducted to assess the problem condition. The lack of snow at the site did not permit measurements to be made. However, it was decided to proceed with this site based on discussions about the problem conditions during previous winters with field crew members. During this visit, it was observed that snowfences were already being installed. However, openings to permit pedestrian access to and from the park were not made. As a result, pedestrians knocked over the fence to gain access.

RECOMMENDED SOLUTION:

The pedestrian routes through the park were studied and the snowfence arrangement shown in Figure D-8-1 was developed for future use.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 4, 1988, a site visit was conducted to assess the effectiveness of the snowfence installation. The developed snowfence layout had been installed and with the exception of a 5m section which was knocked down, the fences were standing. The lack of snow at this site did not permit any snow depth measurements to be made.

2) On March 15, 1989, another site visit was conducted. The fences were installed as shown in Figure D-8-1 except the fence closest to the road was setback 30m from the sidewalk instead of the recommended 20m. Once again the lack of snow at this site

did not permit snow depth measurements to be made.

CONCLUSIONS:

The lack of snow at the site for all three winters of the study does not permit conclusions to be drawn about the effectiveness of the snowfence to minimize the problem conditions. However, it would appear that the snowfencing layout was easier for pedestrians to manoeuvre through as much less fencing was knocked down by pedestrians during the winters that the revised layout was used.

RECOMMENDATIONS:

The continued use of the snowfencing layout shown in Figure D-8-1 is recommended. The City of London should continue monitoring the effectiveness of this solution, at least until a typical winter occurs. At that time, they can assess the continued use of this layout and/or the necessary modifications needed to improve its performance.

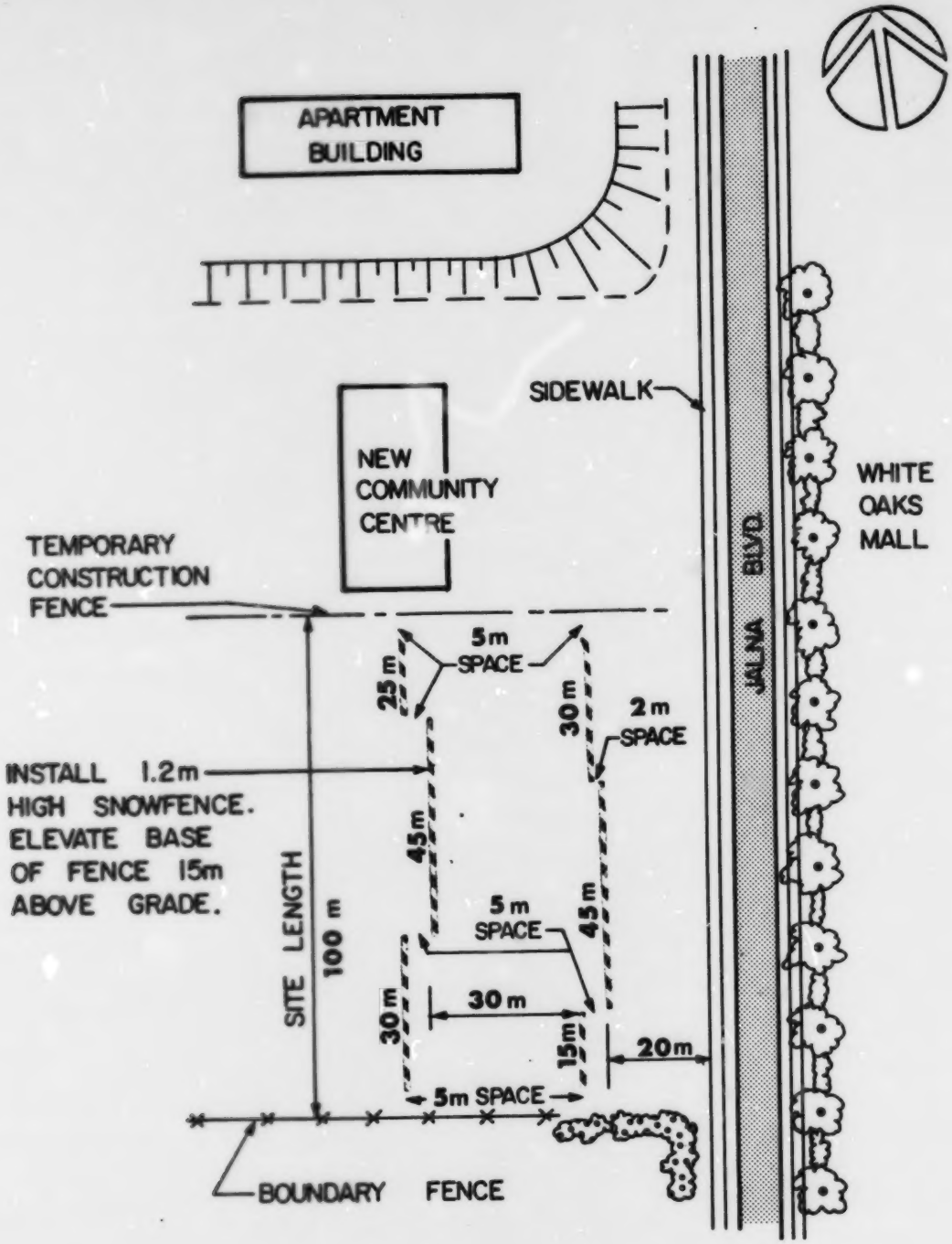


FIGURE D-8-1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1-9 JALNA BLVD., LONDON

APPENDIX D-9

SITE SUMMARY

SITE NUMBER: 1-10

SITE NAME: Peel Regional Road #7

SITE LOCATION: North of Peel Regional Road #9, Sandhill

PROVINCE: Ontario

PRIMARY CONTACTS: Gerry Dolan, Operations Engineer
Region of Peel, Brampton

Ken Adcock, Supervisor
Peel, North District Yard, Victoria

DESCRIPTION OF PROBLEM:

The prevailing westerly winds drift snow across the site which only cause problems during heavy traffic use. As the volume of traffic increases, the snow is packed onto the road causing traction problems.

PROBLEM IDENTIFICATION SITE VISIT:

On February 24, 1987, a site visit was conducted to understand the problem conditions at this site. The problem described above was not observed nor did it occur during this entire winter, since it was less than typical. However, a solution was developed based on the problems experienced during previous winters.

RECOMMENDED SOLUTION:

Based on meteorological data collected at Toronto International Airport and local site conditions, the snowfence arrangement shown in Figure D-9-1 was developed.

SOLUTION ASSESSMENT SITE VISITS:

1) On March 24, 1988 a site visit was conducted to assess the effectiveness of the solution. It was installed as recommended with a few minor variations. However, there was too little snow at the site to make any depth measurements. It was also observed that an intermittent stream runs through the site and the snowfence was extended across it. If significant snow accumulations occur at this section of the fence, they could form a dam which could cause local flooding during spring run off.

2) Although the fences were installed during the 1988-89 winter conditions were such that only one drifting event occurred at this site. It was decided that a site visit was not necessary since there was nothing to record.

CONCLUSIONS:

Snowdrifting conditions were relatively insignificant during the three year study of this site due to a lack of snowfall. Therefore, it is difficult to conclude how effective the solution was.

RECOMMENDATIONS:

The continued use of the snowfencing arrangement shown in Figure D-9-1 is recommended. However, it should be continued to be monitored until it experiences a typical winter. At that time, the Regional Municipality of Peel should assess its continued use as installed or with the necessary revisions.

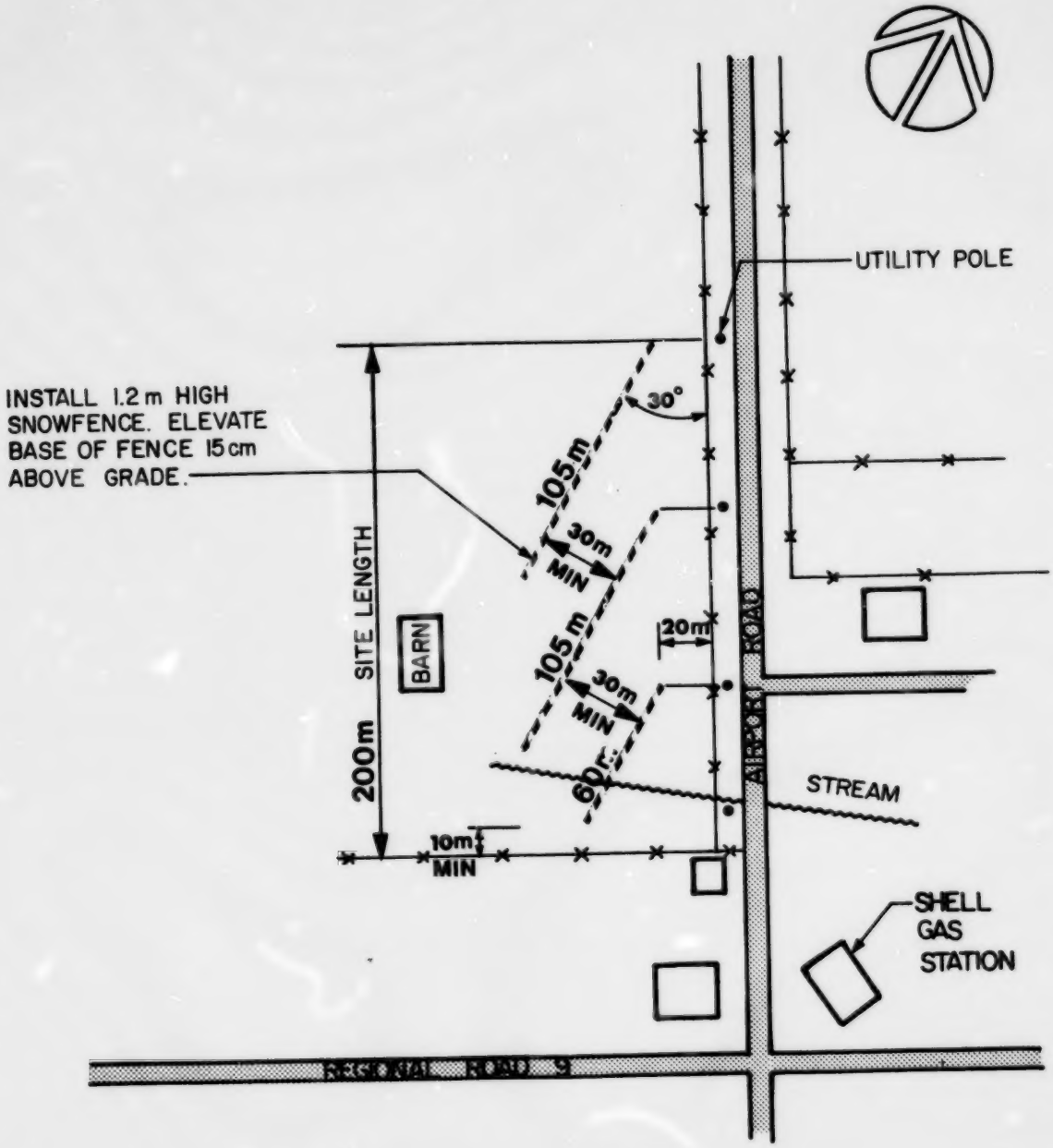


FIGURE D–9–1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1–10 AIRPORT ROAD, SANDHILL

APPENDIX D-10

SITE SUMMARY

SITE NUMBER: 1-11

SITE NAME: Kettleholes - Sudbury Regional Road 86

SITE LOCATION: 0.6 km East of Airport Entrance, Sudbury

PROVINCE: Ontario

PRIMARY CONTACT: Don Belisle, Director of Operations and Maintenance, Regional Municipality of Sudbury

DESCRIPTION OF PROBLEM:

The construction of Regional Road 86 at this site required that a large fill section be created to produce a grade within set guidelines. This fill section separates two geological features called kettleholes. Each kettlehole contains a lake and the surface of each lake is approximately 150 to 200m below the surface of the road. The prevailing winds scour the snow from the sideslopes of the fill section and produce visibility problems over the road surface between the guardrails.

PROBLEM IDENTIFICATION SITE VISIT:

On February 25, 1987, a site visit was conducted to identify the problem condition. It was described that the guardrail causes an obstruction for the snow plow operators. As a result, a snowbank is left. The calm air region behind this obstruction fills with suspended snow particles causing visibility problems over the road. It was agreed that a wind deflector would be installed on the existing guardrails to improve wind flow over the road.

RECOMMENDED SOLUTION:

Install the angled wind deflector as shown in Figures D-10-1 and D-10-2.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 16, 1989, a site visit was conducted to review the effectiveness of the wind deflector. Through the use of photographs taken by the field crews, it was apparent that the deflector was scouring snow from beneath the guardrail. It was also noted that during a snowdrifting event that the visibility had improved at the wind deflectors. However, just prior to this site visit, a large snowfall occurred which virtually plugged the underside of the deflector. Since it would require constant monitoring and continual hand removal of snow to keep the deflector operational, it was not installed during the following winter.

CONCLUSIONS:

Although the wind deflector installed appeared to be effective it was not a practical solution from an operations point of view because the deflector would require manual snow removal to keep it operational.

RECOMMENDATIONS:

Consideration should be given to planting the sideslopes of the fill section. Such a planting should be a minimum of 1.0m high and cover the entire embankment to contain the fallen snow and not permit it to be blown towards the road. In addition, the top of the planting should not extend higher than the level of the road surface.

For more information regarding the landscaping solution, refer to the companion manual.

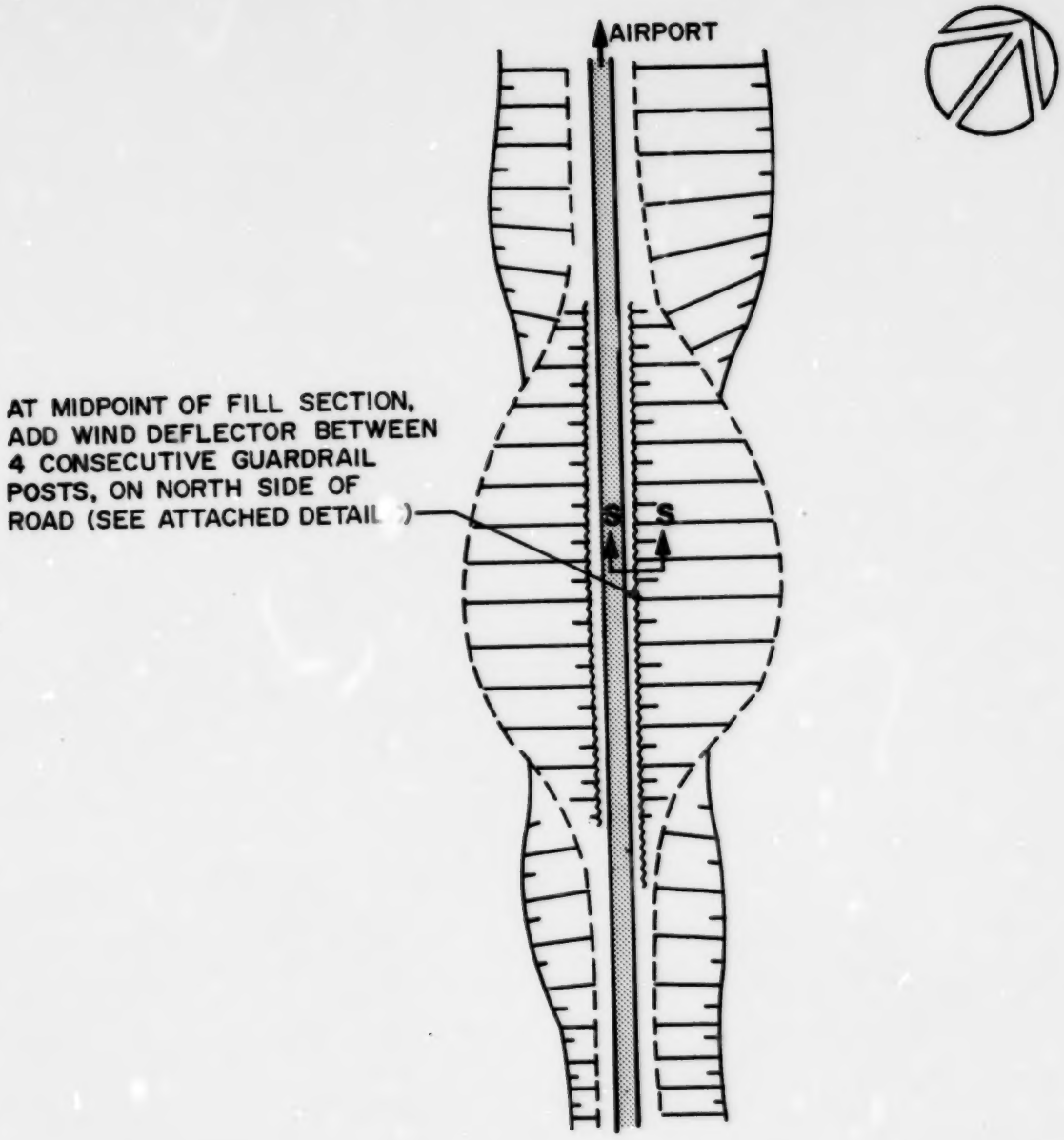

AIRPORT
AT MIDPOINT OF FILL SECTION, ADD WIND DEFLECTOR BETWEEN 4 CONSECUTIVE GUARDRAIL POSTS, ON NORTH SIDE OF ROAD (SEE ATTACHED DETAIL)
S
S

FIGURE D–10–1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1–11 KETTLEHOLES, REGIONAL ROAD 86, SUDBURY

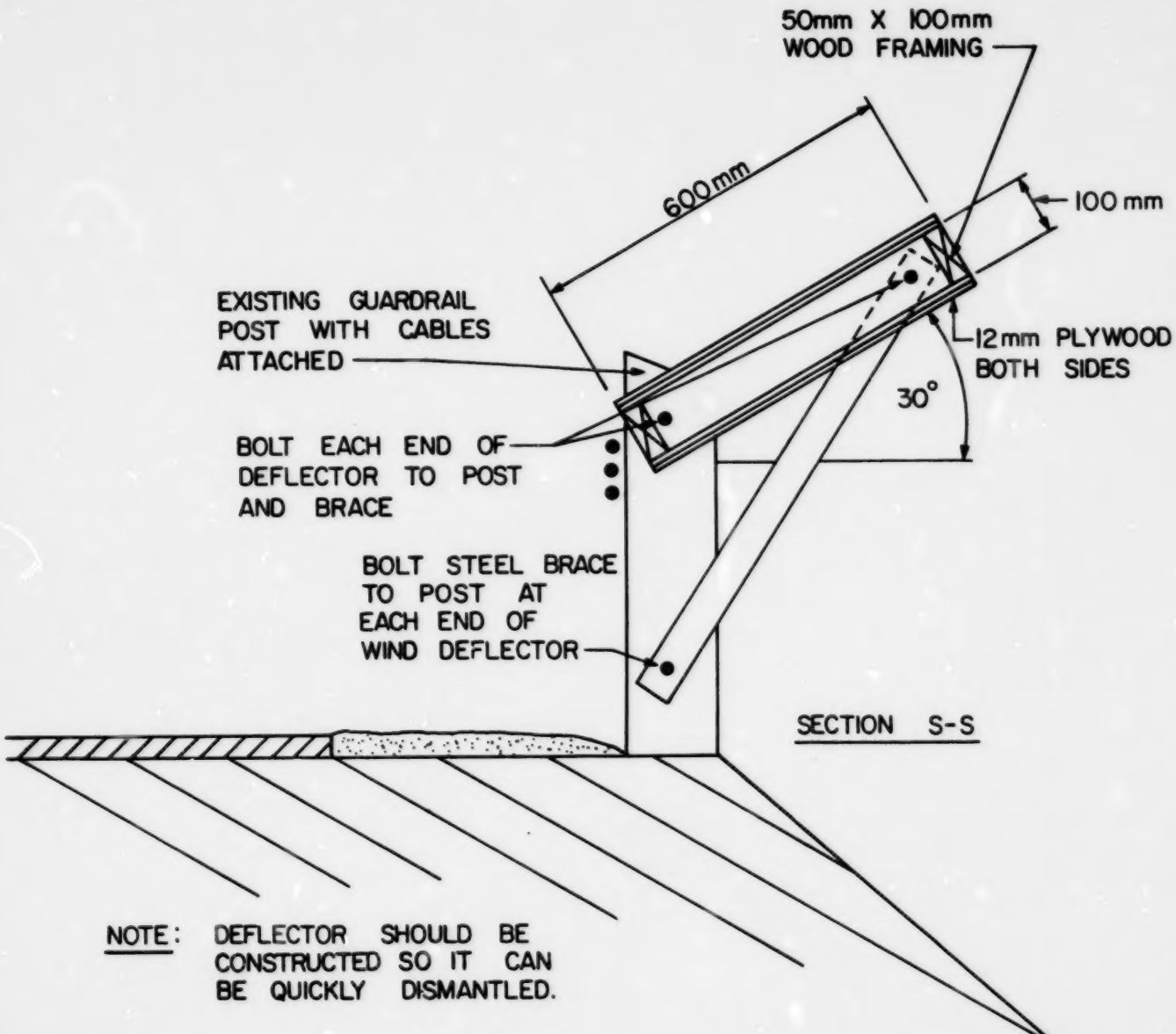


FIGURE D-10-2

DETAILS OF WIND DEFLECTOR

SITE 1-11 KETTLEHOLES, REGIONAL ROAD 86, SUDBURY

APPENDIX D-11

SITE SUMMARY

SITE NUMBER: 1-12

SITE NAME: Sudbury Regional Road 86

SITE LOCATION: 1.5km west of airport entrance, Sudbury

PROVINCE: Ontario

PRIMARY CONTACT: Don Belisle, Director of Operations and Maintenance, Regional Municipality of Sudbury,

DESCRIPTION OF PROBLEM:

The road at this site is adjacent to the airport in a cut section which is approximately 2m deep and 200m long. The recent clearing of trees and shrubs on airport property permits the wind to blow into the cut. Mr. Orval Myers, the Airport Manager, indicates that snowfencing and/or landscaping could be placed on airport property to control this snowdrifting problem.

PROBLEM IDENTIFICATION SITE VISIT:

On February 25, 1987, a site visit was conducted to assess the above mentioned problem. It was agreed that due to the lack of right-of-way space on the upwind side of the road that snowfencing would need to be placed an airport property. During this visit snow accumulations adjacent to the road measured up to 2.0m deep (see graph in Figure D-11-1).

RECOMMENDED SOLUTION:

Based on site information and meteorological data recorded at Sudbury Airport, a snowfencing arrangement was developed as shown in Figure D-11-2, excluding the 75m long 1.2m high fence.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 16, 1988, the first solution assessment site visit was conducted. During that visit, it was noted that only 1.2m high fences had been installed, instead of the recommended 2.5m height. It was explained that the intent was to erect the additional 1.2m fencing on top of the initial installation if needed later in the winter. Since the current fencing had just filled with snow over the previous week or so, it was decided by the Region of Sudbury that winter would soon be over and the additional fence would not be installed.

The snowfences had not worked well as there was not sufficient overlap in the middle of the arrangement and snow was passing through to the road. The graph in Figure D-11-1 shows the improved accumulation adjacent to the road during the 1987-88 winter, however, significant amounts of snow accumulated on the backslope of the cut. It was decided that the fencing would be extended in the mid section of the site as shown in Figure D-11-2 prior to the next winter.

2) On February 23, 1989, another side visit was conducted to assess the effectiveness of the installed fences. It was observed that the revised layout shown in Figure D-11-3 was installed and similar to the previous winter the supplementary lift of snowfence had not been added yet. As can be seen in Figure D-11-1 the accumulations at the road had been reduced significantly over the two previous winters.

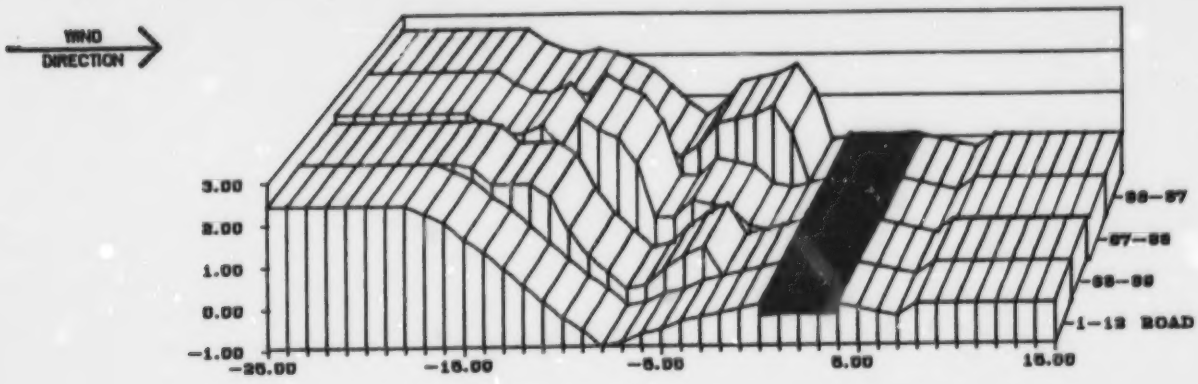
CONCLUSIONS:

From Appendix F it can be noted that the meteorological data recorded at Sudbury Airport was similar for the 3 year test program. The accumulations adjacent to the road were reduced substantially by the addition of snowfencing. As the peak ground snow cover recorded at this site would be exceeded on an average every 3-4 years it is possible that problem conditions could still be expected in a similar time frame. It could be concluded that the use of the additional lift of snowfence may be needed periodically in the future.

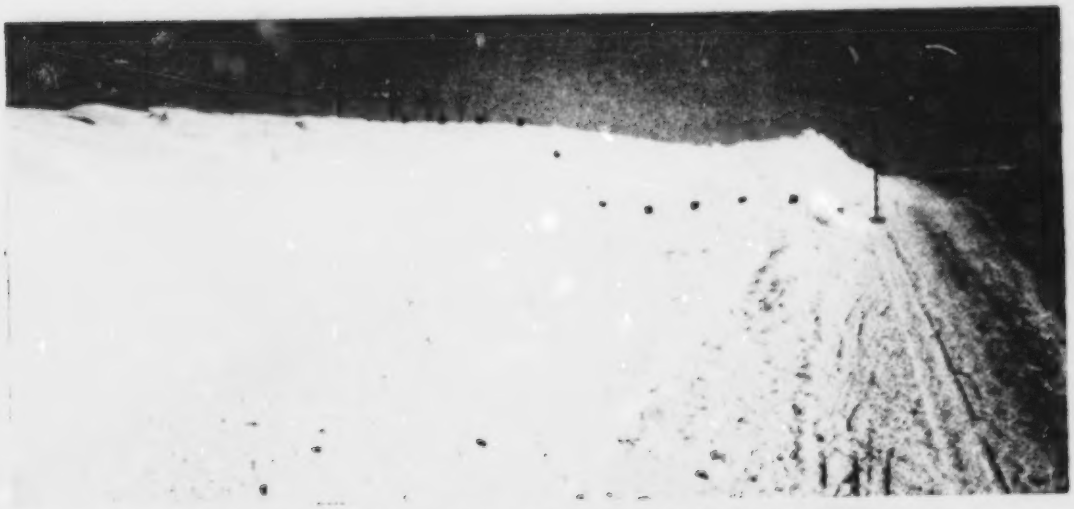
RECOMMENDATIONS:

It is recommended that the snowfencing layout shown in Figure D-11-3 be used in the future. However, this installation requires regular monitoring so that if the initial lift of snowfence fills with snow the appropriate action can be taken to install the second lift shortly thereafter.

For long range plans the snowfencing could be replaced by a single row of closely spaced 5m high coniferous trees located a minimum of 50m from the boundary fence. Caution should be taken when planting these trees to ensure that they are planted on the crest of any rises in land from in the area. If placed in a depression or valley, they will not perform effectively.



TYPICAL CROSS SECTION AT STUDY SITE



PHOTOGRAPH OF 1987-88 SNOW ACCUMULATIONS

PHOTOGRAPH OF 1988-89 SNOW ACCUMULATIONS

FIGURE D-11-1

TYPICAL SNOW ACCUMULATIONS

SITE 1-12 REGIONAL ROAD 86, SUDBURY AIRPORT

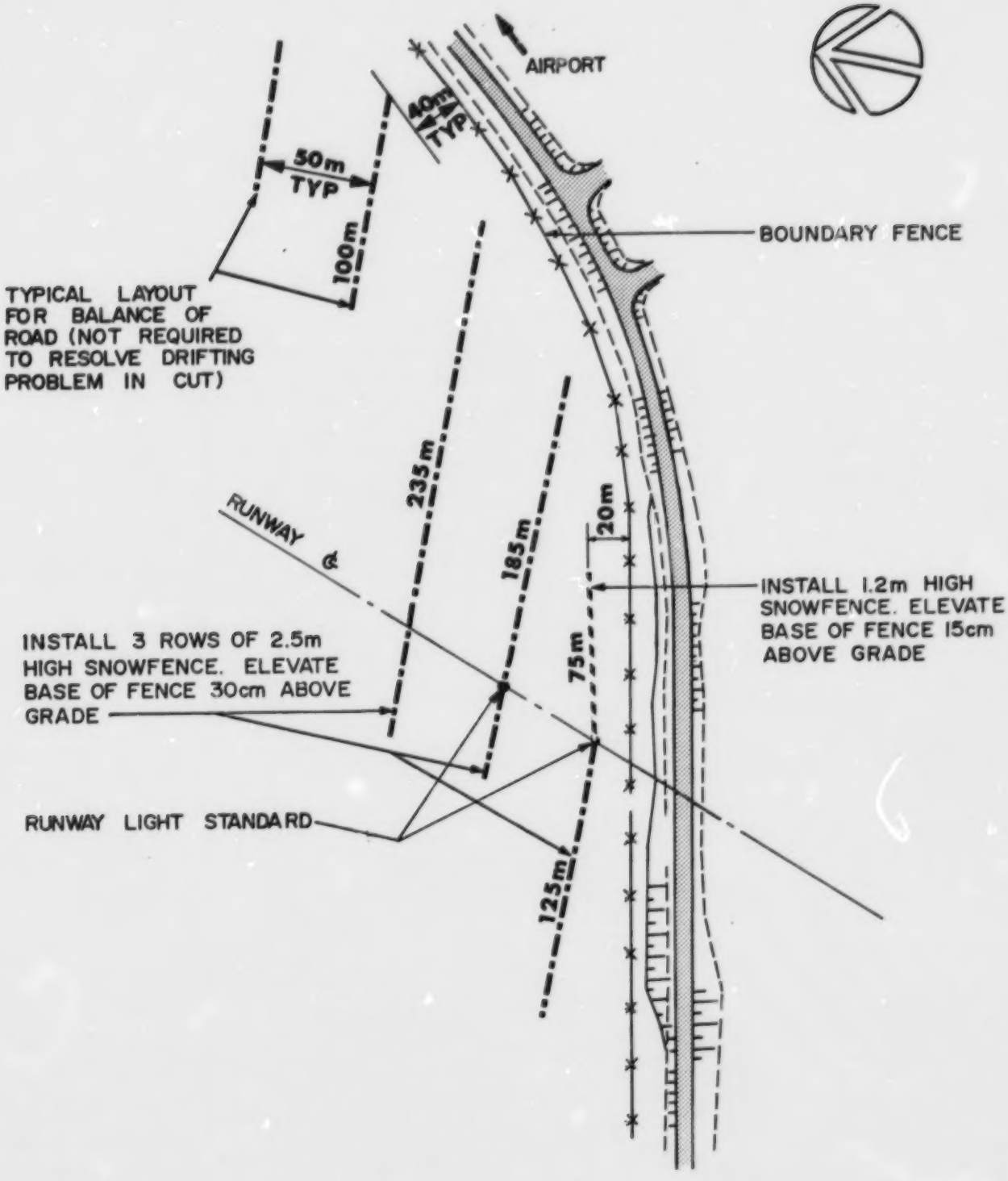


FIGURE D–11–2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1–12 REGIONAL ROAD 86, SUDBURY AIRPORT

APPENDIX D-12

SITE SUMMARY

SITE NUMBER: 1-13

SITE NAME: Foster Drive Park

SITE LOCATION: Waterfront - Sault Ste. Marie

PROVINCE: Ontario

PRIMARY CONTACT: Mel W. Brechin, P.Eng.,
Director of Public Works
City of Sault Ste. Marie

DESCRIPTION OF PROBLEM:

The park at this site is located between the St. Marys River and Foster Drive. The prevailing winds blow off the river towards Foster Drive. The park does not have any vegetation except for the short grass which covers the entire area. The only landscaping feature is a 2m high berm that has been placed adjacent to Foster Drive and this causes snow to accumulate frequently on the sidewalk and adjacent street. Future development of this area is planned which would include the addition of trees to the park. Therefore, the solution should consider the use of coniferous trees and/or dense deciduous shrubs.

PROBLEM IDENTIFICATION SITE VISIT

On February 26, 1987, a site visit was conducted to gather information on the problem conditions experienced at the site. Although the above mentioned accumulations had not been severe enough to reach the road, they had affected the sidewalk (see Figure D-12-1). Accumulations of up to 1.0m deep occurred on both sides of the sidewalk. The bare ground on top of the berm suggested a local scouring condition which could be best treated by localized ground cover or low shrubs. Since a temporary solution could not be developed, it was agreed that a snowfencing arrangement would be developed to control the drifting snow entering the park thereby determining the localized impact at the berm by observing the resultant drifting on the sidewalk and roadway.

RECOMMENDED SOLUTION:

Based on local site conditions and meteorological data recorded at Sault Ste. Marie Airport, the snowfencing arrangement shown in Figure D-12-2 was developed.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 17, 1988, a site visit was conducted to assess the effectiveness of the solution. It was observed that a boat was placed in dry dock at the park approximately 30m southwest of the berm and that two openings approximately 10m had been left in the fence to the west of the berm to allow vehicular access to the boat. These openings were staggered to reduce the possibility of drifting snow from reaching the berm. Although the fences had collected snow measuring up to 1.0m deep there were still snow accumulations at the sidewalk adjacent to the berm. These accumulations measured 1.0m, similar to the previous year. In addition, the scoured area at the top of the berm still existed.

2) Due to construction at the site during the 1988-89 winter, the solution was not installed and subsequently snow measurements were not taken.

CONCLUSION:

From Appendix F, it can be determined that the 1986-87 winter was slightly less than typical and 1987-88 was an average winter. It would appear that the problem which is experienced at the site would be a greater than average winter and that the problem is largely due to the localized drifting at the berm. Although snowfencing is helping reduce the volume of snow blowing towards the road, landscaping the berm or removing it would be the probable solution.

RECOMMENDATION:

Assuming the local construction does not significantly change the terrain at the park, it is recommended that if the berm cannot be removed that it be landscaped on the west through southwest sides with 0.5 - 1.0m high dense shrubs and that the temporary snowfencing be included to minimize the amount of snow entering the park from the prevailing wind directions.

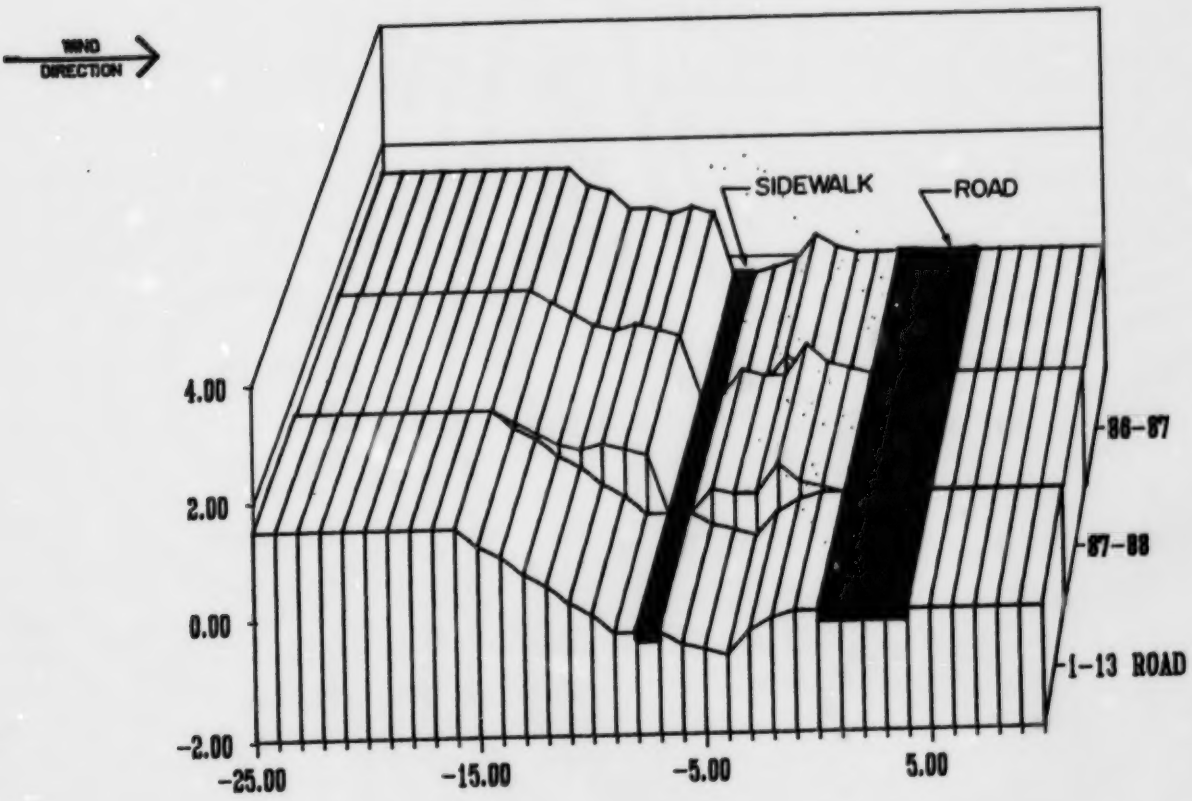


FIGURE D-12-1
TYPICAL SNOW ACCUMULATIONS
SITE 1-13 FOSTER DRIVE PARK, SAULT STE. MARIE

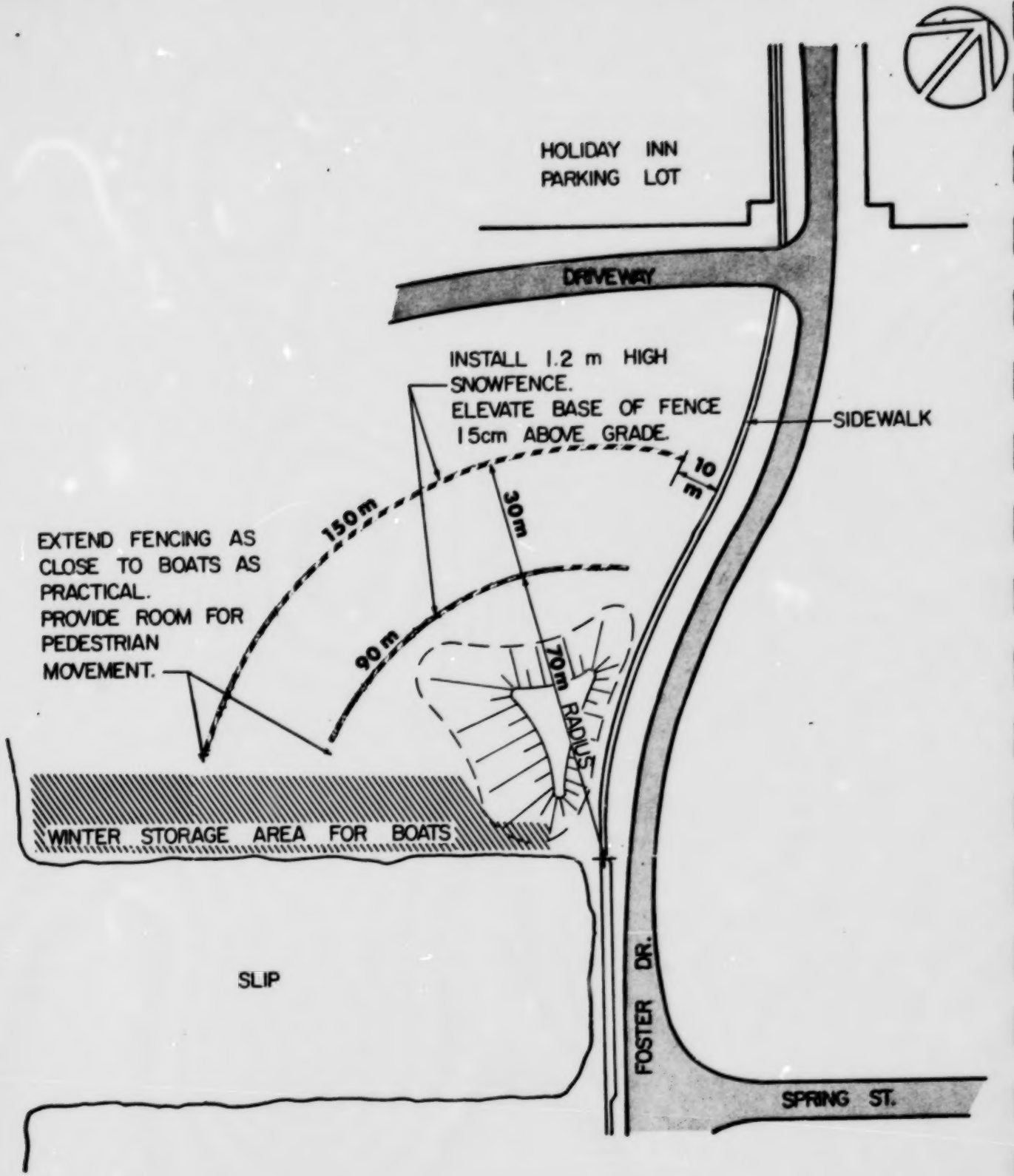


FIGURE D–12–2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1–13, FOSTER DRIVE PARK, SAULT STE. MARIE

APPENDIX D-13

SITE SUMMARY

SITE NUMBER: 1-14

SITE NAME: Highway 550

SITE LOCATION: 1.3 km west of Allen Sideroad, Sault Ste. Marie

PROVINCE: Ontario

PRIMARY CONTACT: Mel W. Brechin, P.Eng.,
Director of Public Works
City of Sault Ste. Marie

DESCRIPTION OF PROBLEM:

Highway 550 is oriented in an east-west direction at this site. The northwest winds cause visibility problems for west bound motorists after they pass through a small built-up area into this relatively open site, which is approximately 275m long. Currently snowfencing has been used with limited success. Mr. Brechin would like a more effective fencing arrangement developed.

PROBLEM IDENTIFICATION SITE VISIT:

On February 26, 1987, a site visit was conducted of the study site and it was observed that visibility problems occur at both the study and reference sites similar to the lower photograph in Figure D-13-1. Normally at a site which experiences a mean annual snowfall over 300 cm it would be recommended that 2.5m high snowfencing be installed. The City Public Works department was not prepared to use this height of fence and it was agreed to install multiple rows of 1.2m high fences instead.

RECOMMENDED SOLUTION:

Based on site conditions and weather data collected at the Sault Ste. Marie Airport, the snowfencing arrangement shown in Figure D-13-2 was developed.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 17, 1988, a site visit was conducted to assess the effectiveness of the solution. As shown in Figure D-13-1, the installed fencing has reduced the accumulations at the study site along with improving visibility when compared with the reference site. Based on snowfall and prevailing wind conditions at the site this year would be considered an average winter.

2) On February 22, 1989, another site visit was conducted. This time it was noted that not all of the fencing shown in Figure D-13-2 was installed. The centre most fence

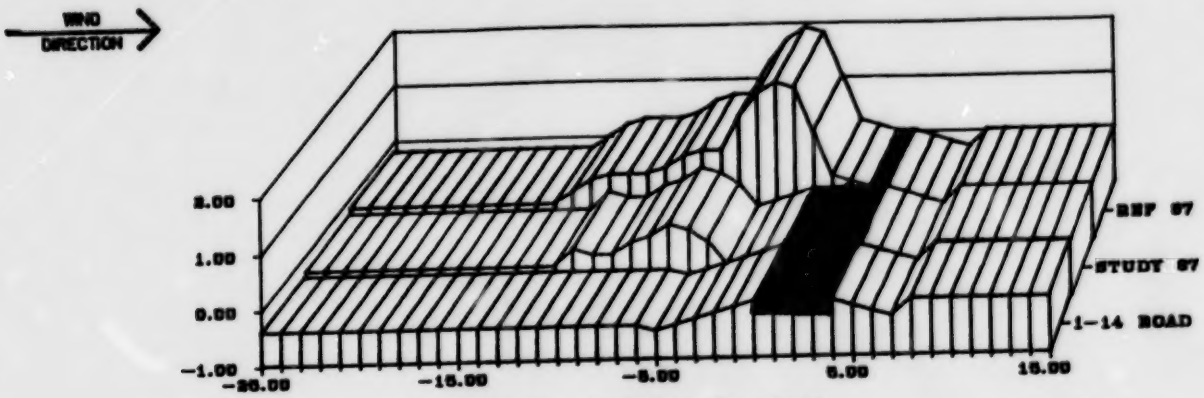
and half of the most westerly fence were not installed. With only 65% of the recommended snowfencing installed the previous year, it is expected that the solution would perform less efficiently than the previous year, as it did. The fences were filled and a substantial snowbank had built up adjacent to the road. Another reason for the reduced efficiency at this site could have been as a result of the heavier than average snowfall this winter coupled with the tall ground cover which reduced the effective height of the snowfences.

CONCLUSIONS:

On an average winter, the above mentioned solution would work satisfactorily. However, when a slightly heavier than average snowfall occurs, it does not. It would appear that an increased height fence be considered.

RECOMMENDATIONS:

It is recommended that snowfencing be continued to be installed at this site. However, it would also be recommended that taller (2.5m) fences be used. This would not require significantly more fencing material than was used during the 1987-88 winter since such a revision would require approximately half as many rows of fence with double height. Guidelines for such an installation can be found in the manual which is being prepared as a companion to this study.



CROSS SECTION OF ROAD

PHOTOGRAPH OF STUDY SITE 1987-88

PHOTOGRAPH OF REFERENCE SITE 1987-88

FIGURE D-13-1

TYPICAL SNOW ACCUMULATIONS

SITE 1-14 HIGHWAY 550, SAULT STE. MARIE

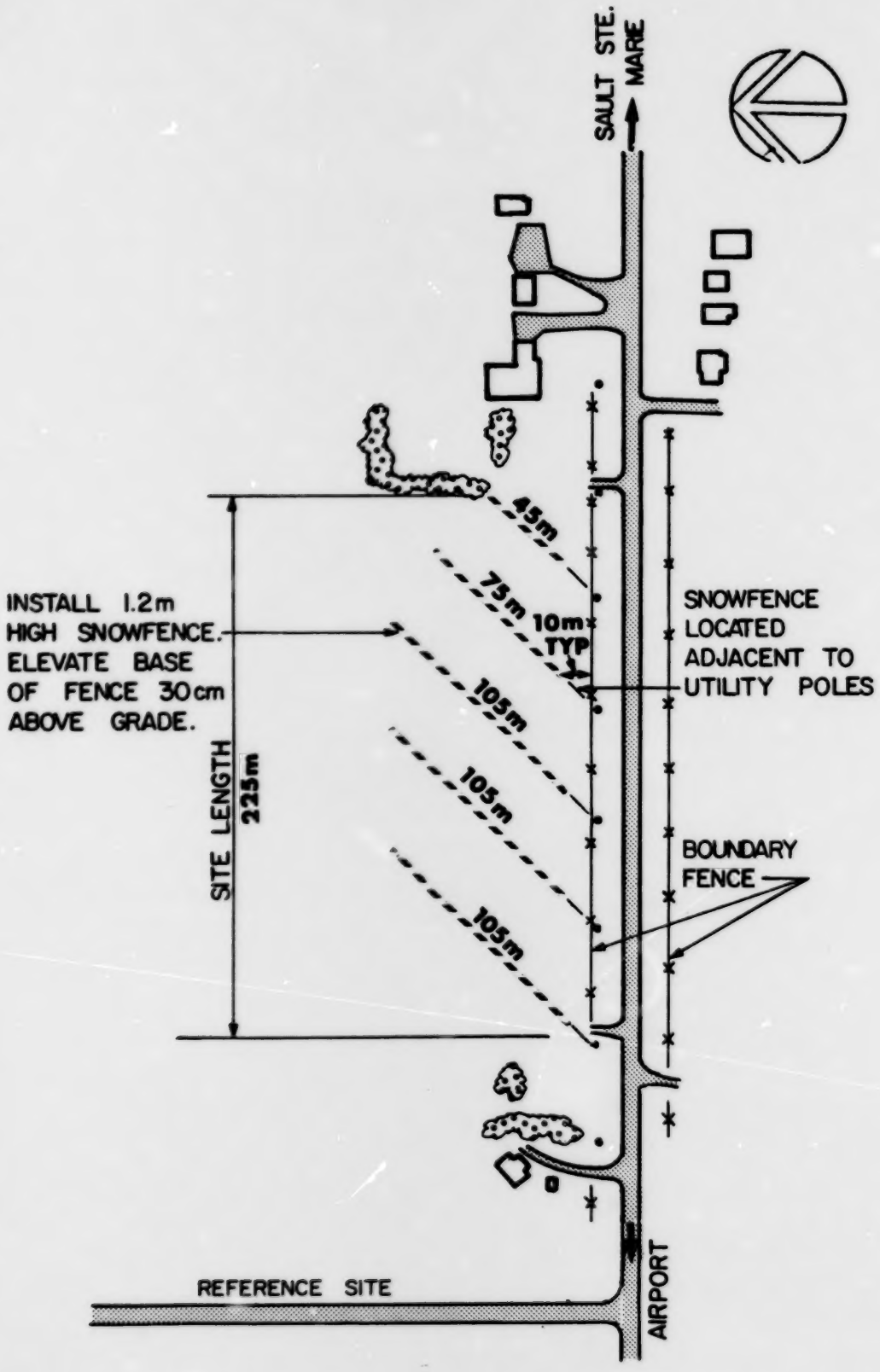


FIGURE D–13–2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1–14 HIGHWAY 550, SAULT STE. MARIE

APPENDIX D-14

SITE SUMMARY

SITE NUMBER: 1-16

SITE NAME: Grey County Road 1

SITE LOCATION: 0.9 km North of Presque Isle Road - Owen Sound

PROVINCE: Ontario

PRIMARY CONTACT: Gary Shaw, Maintenance Manager
Grey County, Owen Sound

DESCRIPTION OF PROBLEM:

The road at this site is oriented in a north-south direction. A 15-20m wide row of 15m high coniferous and deciduous trees are located approximately 10 to 15m from the west side of the road. The lower branches of these trees have died along with the secondary tree growth, permitting the snow to blow beneath the trees. By the time the snow reaches the road, the wind speed decreases and deposits the snow on the road.

PROBLEM IDENTIFICATION SITE VISIT:

On March 3, 1987, a site visit was conducted to observe the above problem conditions. A number of snow accumulation depth profiles were measured from the road westward through the trees typically these accumulations measured up to 1.5m deep at the road and approximately 0.2m within the trees. Figure D-14-1 illustrates these accumulations. At the reference location, approximately 200m north of the site, the trees have not died away and thus are very dense at ground level. At this location, the maximum accumulations at the road were measured as 0.6m.

It was agreed that the trees at the problem site needed increased density and that this could be accomplished by adding snowfences on the upwind side of the trees.

RECOMMENDED SOLUTION:

As shown in Figure D-14-2, it was recommended that at 2.5m high snowfence be erected at the west edge of the trees, using the trees for support wherever possible.

SOLUTION ASSESSMENT SITE VISITS:

1) On March 3, 1988, a site visit was conducted to assess the effectiveness of the installed solution. It was observed that the recommended fence had been erected except for the portion adjacent to the driveway to the R. Waite Residence. Here the fencing was not installed in particular adjacent to the opening in the trees shown in Figure D-14-2. This location serves as a reference to the problem condition. Here

snow accumulations measuring up to 2.0m deep were recorded adjacent to the road (upper photo Figure D-14-1). These depths compare to less than 1.0m where the fences were installed (lower photo Figure D-14-1). As well the snow accumulations at the 1987 reference site were measured to be less than 1.0m.

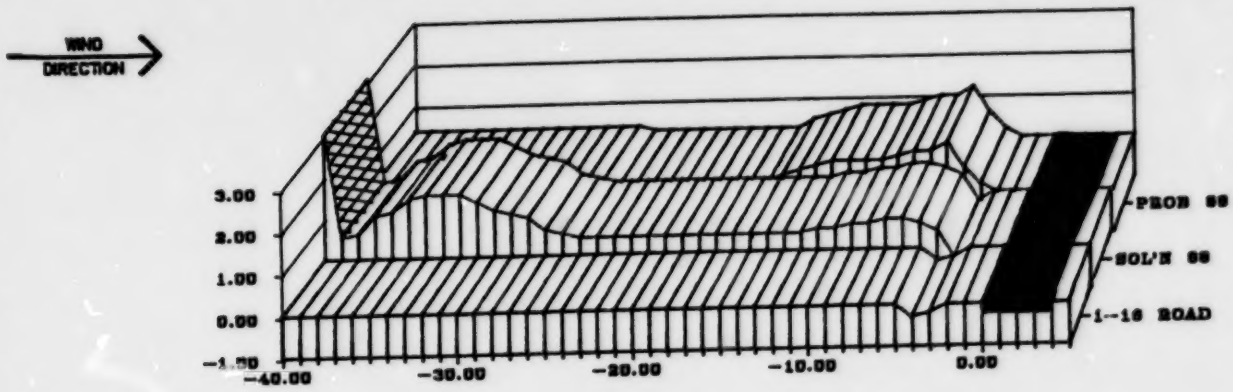
During the site visit, Mr. Shaw remarked that installing the fence was relatively simple were the trees could be used for support. However, in the openings along the tree row, posts were required to support the fence. Due to the rocky terrain it was difficult to drive the posts into the ground. As a result, alot of lateral bracing was required to support the fence. Due to the installation costs involved, the County of Grey were not interested in erecting the fence again in the future. However, they were convinced that the fence was effective in increasing the density of the existing trees.

CONCLUSIONS:

From Appendix F, it can be noted that the 1987 - 88 winter in nearby Wiarton was less than average but significantly more severe than the 1986 - 87 when the amounts of snowfall and numbers of observations of blowing snow are compared. It can be concluded that the fence was effective in resolving the problem. However, it can also be concluded that soil conditions play a critical role in the success (both physically and financially) of a solution and as a result, alternative solutions may be necessary.

RECOMMENDATIONS:

It is recommended that if it is not feasible to install the snowfence shown in Figure D-14-2 that a replanting program begin immediately to fill the gaps in the trees with coniferous trees which will ultimately reach a minimum of 5m in height.



TYPICAL CROSS SECTION AT STUDY SITE

PROBLEM CONDITION 1987–88 WINTER

WITH SNOWFENCE INSTALLED 1987–88

FIGURE D–14–1
TYPICAL SNOW ACCUMULATIONS
SITE 1–16 GREY COUNTY ROAD 1

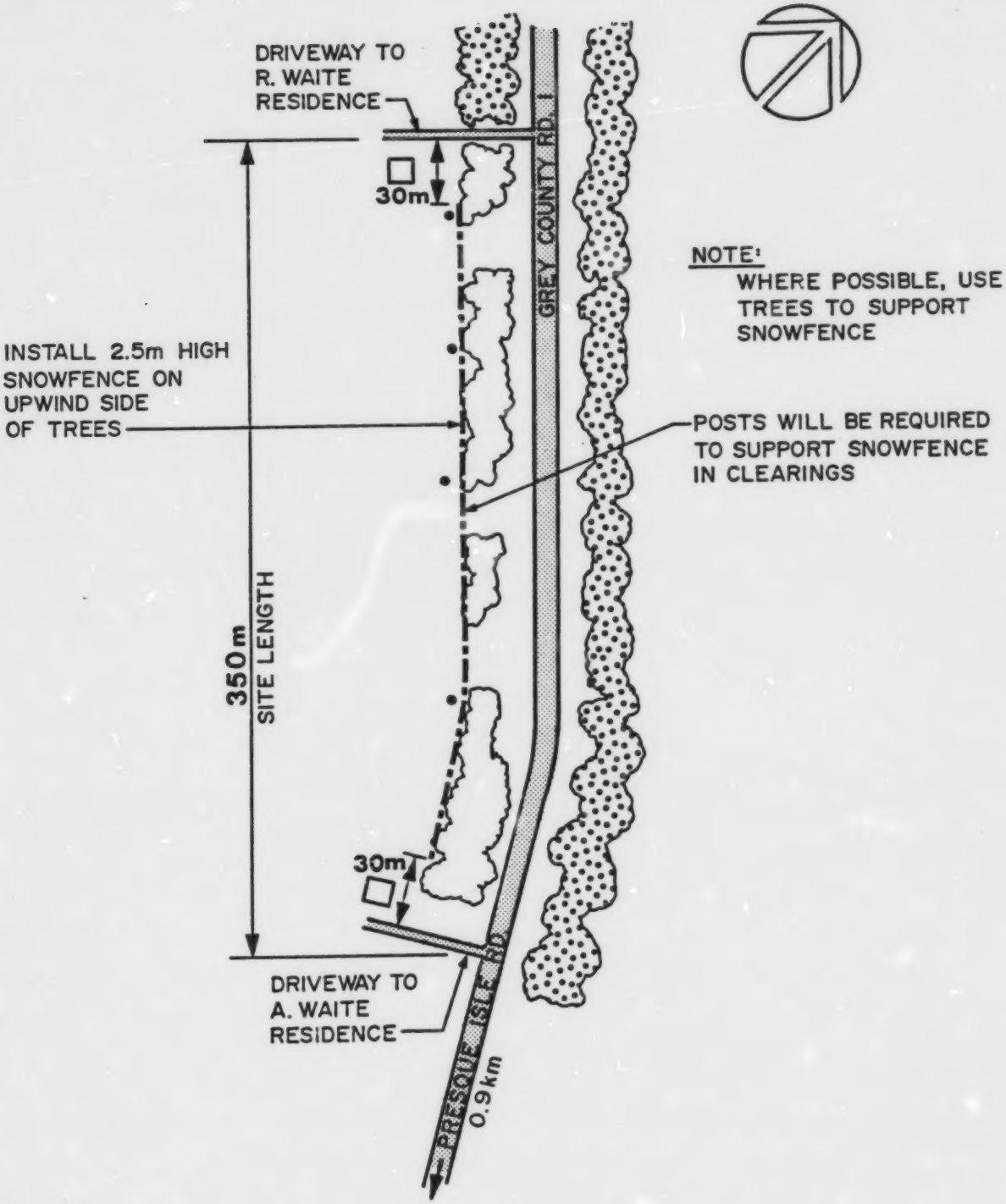


FIGURE D-14-2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1-16 GREY COUNTY ROAD 1

APPENDIX D-15

SITE SUMMARY

SITE NUMBER: 1-17

SITE NAME: Prince of Wales Drive

SITE LOCATION: North of Baseline Road - Ottawa

PROVINCE: Ontario

PRIMARY CONTACT: Jim Becking, Director of Operations
The Regional Municipality of Ottawa-Carleton

DESCRIPTION OF PROBLEM:

This suburban site is located on a bend in the road which is exposed to winds from the west direction. The snow which drifts onto the road sticks to the surface causing a loss of traction.

PROBLEM IDENTIFICATION SITE VISIT:

On March 4, 1987, a site visit was conducted to assess the problem conditions at this site. Although the problem identified above was not observed, a snowfencing solution was developed based on a description of the problem by Clark Dero (RMOC).

RECOMMENDED SOLUTION:

Based on site conditions and meteorological data recorded at Ottawa International Airport, a snowfencing solution was developed as shown in Figure D-15-1. Since the adjoining property is not part of the street right-of-way, a permanent solution could not be considered therefore temporary snowfencing was necessary.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 18, 1988, a site visit was conducted to observe the effectiveness of the installed solution. The snowfencing shown in Figure D-15-1 was installed and had accumulated snow to depths of up to 1.1m. Since the winter was not representative of a typical winter, the lack of snow resulted in these minimal accumulations. Due to the light winter, there were no apparent changes in road conditions caused by the fencing.

2) On March 9, 1989, a third site visit was conducted. Once again a less than typical winter occurred resulting in maximum accumulations at the fences between 0.5 and 1.0m deep.

During this visit it was reported by Mr. Becking that on March 1, 1989, a snowdrifting situation occurred where the snowfencing was not collecting the snow before it reached the road. Weather data collected at nearby Ottawa International Airport indicated that winds from the west-southwest occurred which is generally in-line with the snowfences. Therefore the snow would blow between the fences and towards the road, thus the problem. From Appendix F, winds from the west-southwest are not typical and adjusting the snowfence layout would not be warranted.

CONCLUSIONS:

Due to a lack of typical snowdrifting conditions at this site during the 3 year study, definite conclusions cannot be made about the effectiveness of the snowfence arrangement.

RECOMMENDATIONS:

The continued use of the snowfence arrangement shown in Figure D-15-1 is recommended until it experiences a typical winter. At that time, its continued use either in its present form or revised layout can be determined.

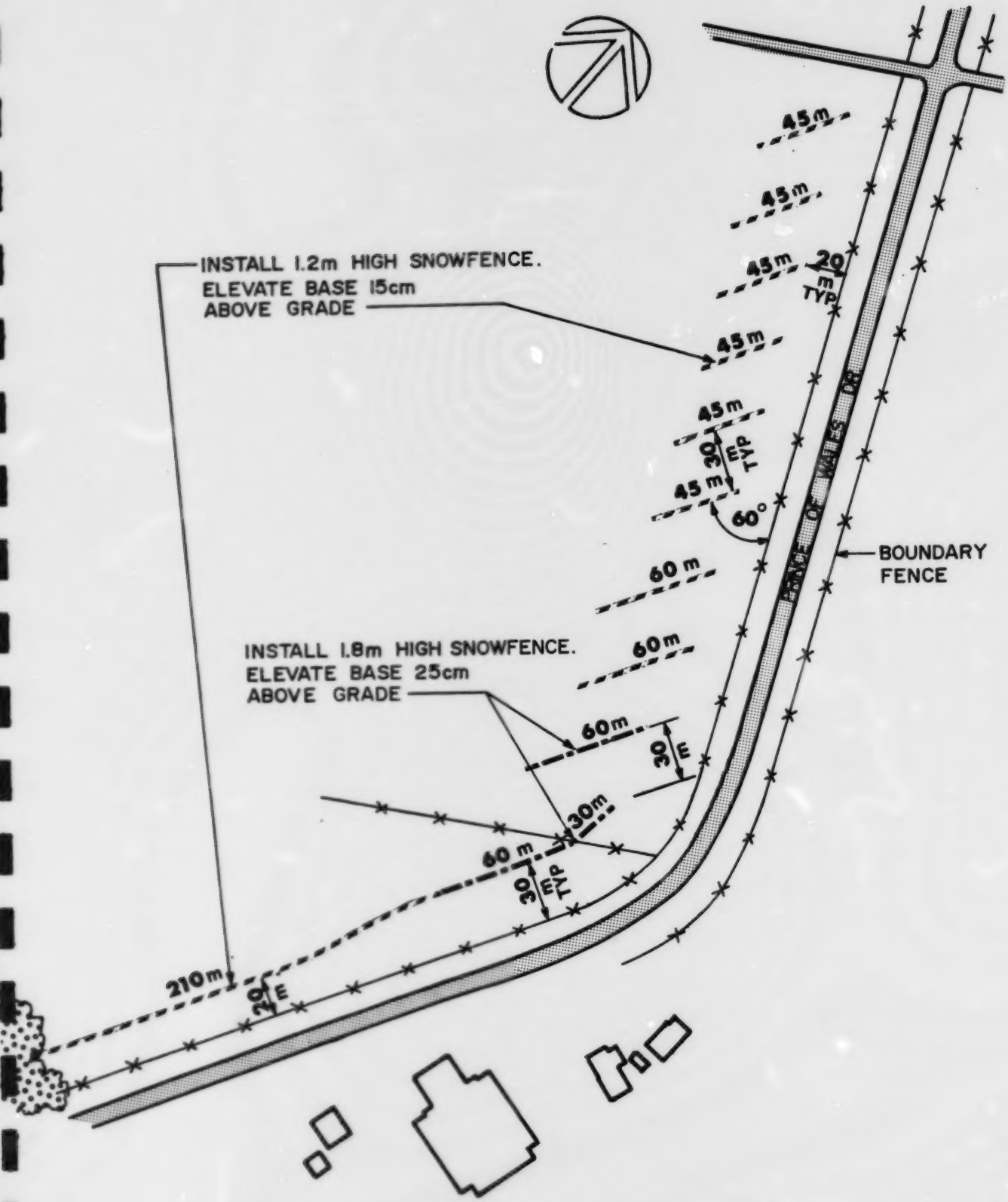


FIGURE D–15–1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1–17 PRINCE OF WALES DRIVE, OTTAWA

APPENDIX D-16

SITE SUMMARY

SITE NUMBER: 1-18

SITE NAME: Ottawa-Carleton Regional Road 3

SITE LOCATION: At Mantil Side Road - Ottawa

PROVINCE: Ontario

PRIMARY CONTACT: Jim Becking, Director of Operations
The Regional Municipality of Ottawa-Carleton

DESCRIPTION OF PROBLEM:

Regional Road 3 is oriented in a northwest-southeast direction at this site and has a cut section on the east side of the road. Westerly winds cause snow to drift across the road and deposit on the east side of the road on the upwind side of the cut. This problem is compounded by the limited storage area for plowed snow on the same side of the road. As a result, snow has to be frequently pushed to the ditch on the west side of the road.

PROBLEM IDENTIFICATION SITE VISIT:

On March 5, 1987, a site visit was conducted to observe the above mentioned problem condition. Although the problem was not severe during this winter, the accumulations of snow were evident on the east side of the road as shown in Figure D-16-1. Since easterly winds are also prevalent at this site, it was assumed that some drifting could occur from that direction and as a result a snowfencing arrangement was also developed for the east side of the road.

RECOMMENDED SOLUTION:

Based on local site conditions and meteorological data gathered at Ottawa International Airport, the snowfencing arrangement shown in Figure D-16-2 was developed.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 18, 1988, a site visit was conducted to assess the effectiveness of the solution. It was observed that the solution was installed as recommended but the accumulations were minimal due to a less than typical winter. In fact, the accumulations which occurred were for a single snowdrifting event which occurred approximately one week before involving a 30 cm snowfall followed by winds from the northwest. As can be seen in Figure D-16-1, these conditions produced accumulations along the road of less than 0.5m and up to 1.0m deep on the downwind side of the snowfence.

2) On March 8, 1989, another site visit was conducted and it was observed that the snowfencing had been installed as recommended. Once again the winter was less than typical and the snow accumulations recorded at the site were less than those observed the year before (see Figure D-16-1).

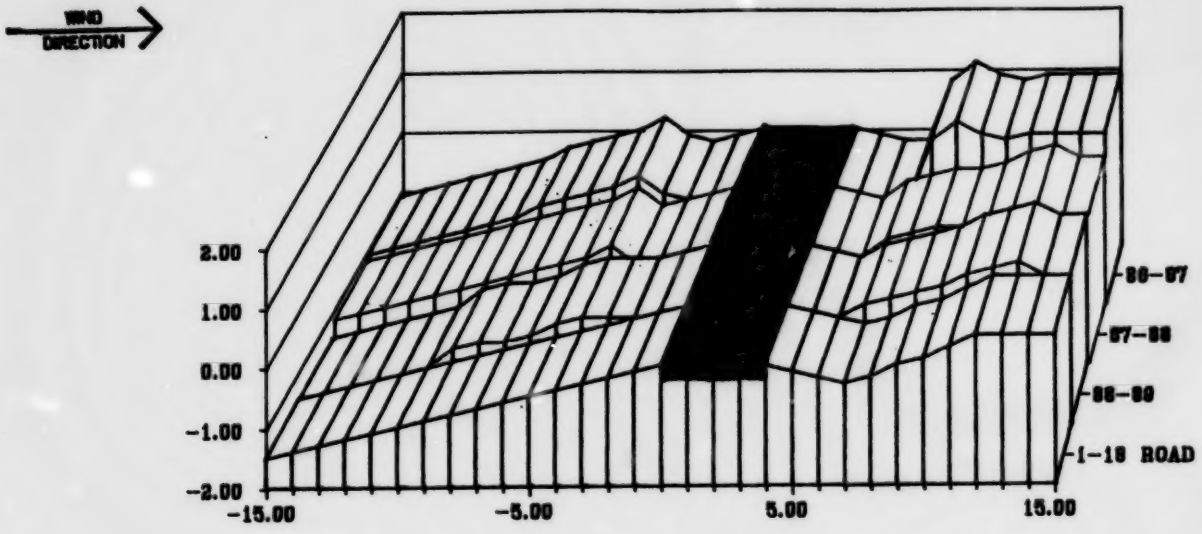
CONCLUSIONS:

Although the snow conditions were less than typical during the three study years, there was enough snowdrifting to determine that the snowfences were located correctly on the west side of the road to effectively collect the snow which drifts from the westerly directions. However, due to the lack of accumulations at the fences located on the east side, it is unlikely that significant volumes of snow drift from the easterly wind directions.

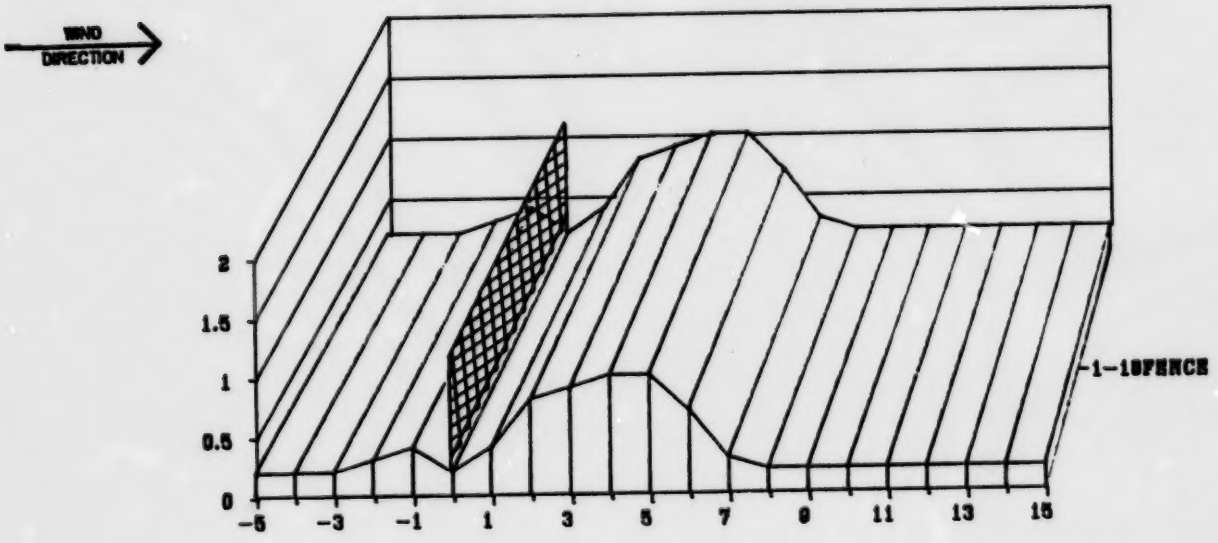
It was also determined that approximately 6.4 cubic metres of snow accumulated for each metre length of each 1.2m high snowfence for the single drifting event which occurred in early February 1988.

RECOMMENDATIONS:

It is recommended that the Region of Ottawa-Carleton continue to use the fencing arrangement shown in Figure D-16-2 with the exception that the fencing shown on the east side of the road be excluded. Since this solution has not been observed during a typical winter, it is also recommended that the field crews continue to monitor the solution. Once a typical winter occurs, its continued use either in its current or revised arrangement should be re-evaluated.



TYPICAL CROSS SECTION OF STUDY SITE



TYPICAL 1.2m HIGH SNOWFENCE (1987-88)

FIGURE D-16-1

TYPICAL SNOW ACCUMULATIONS

SITE 1-18 OTTAWA CARLETON REGIONAL ROAD 3

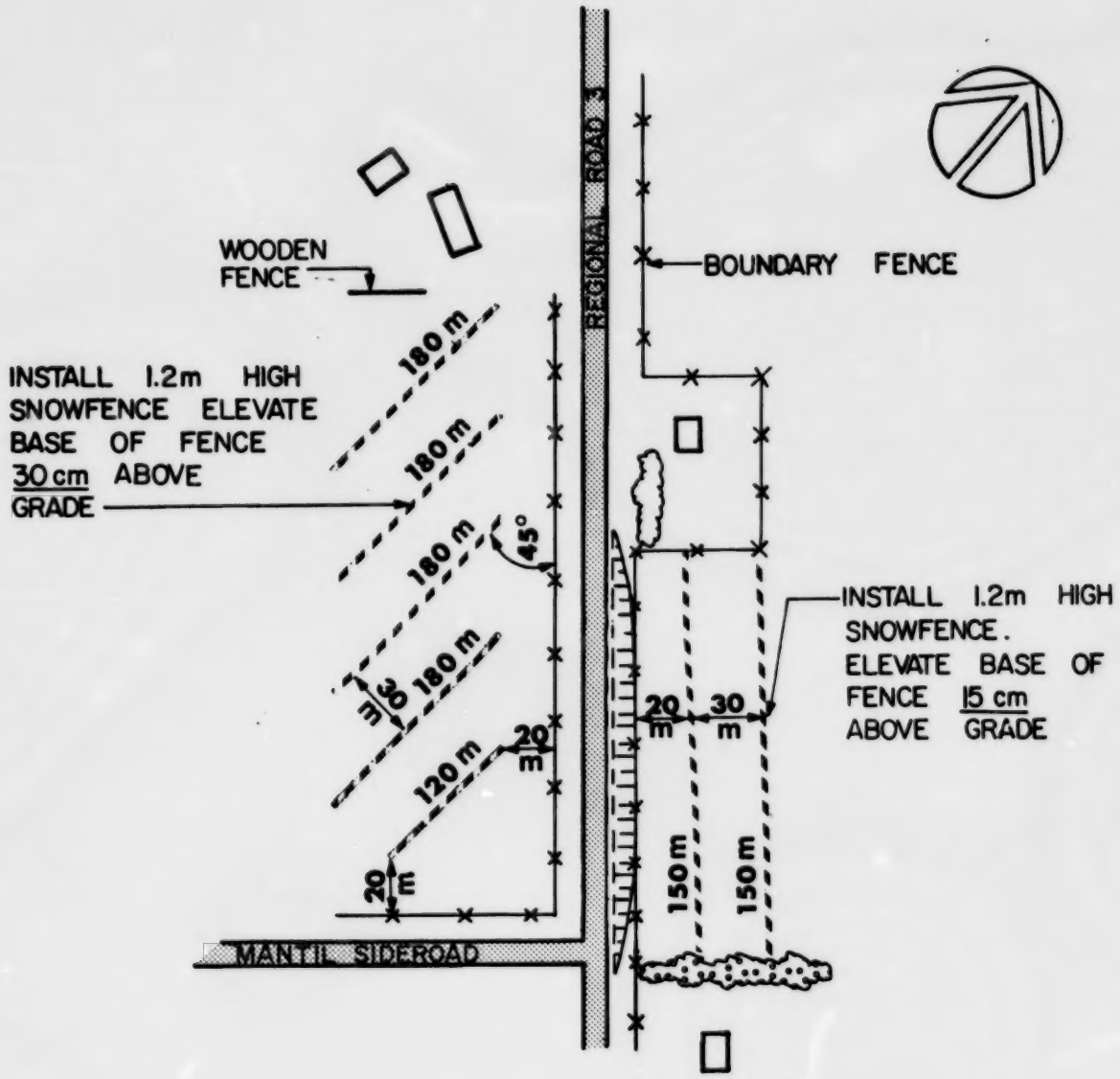


FIGURE D-16-2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1-18 OTTAWA CARLETON REGIONAL ROAD 3

APPENDIX D-17

SITE SUMMARY

SITE NUMBER: 1-19

SITE NAME: Fallowfield Road

SITE LOCATION: Between Moodie and Greenbank Roads - Ottawa

PROVINCE: Ontario

PRIMARY CONTACT: Jim Becking, Director of Operations
The Regional Municipality of Ottawa-Carleton

DESCRIPTION OF PROBLEM:

Fallowfield Road is affected by snowdrifting caused by westerly winds and the plowed snowbanks left on the upwind side of the road. Besides causing accumulations on the road, the snowbanks cause visibility problems. Mr. Becking has used snowfencing in this vicinity in the past. However, the layout used has not produced effective results. He would still like to use snowfencing at this site, and would like us to provide a more effective fencing layout.

PROBLEM IDENTIFICATION SITE VISIT:

On March 5, 1987, a site visit was conducted to assess the above mentioned problem condition. Although the visibility problems were not observed, the snow accumulations along the north side of the road were recorded as illustrated in Figure D-17-1. From Appendix F it can be noted that weather conditions recorded at Ottawa International Airport were less than typical during the 1986-87 winter.

RECOMMENDED SOLUTION:

It was approved by Mr. Becking that this site be used to experiment with the number of rows of fence needed to protect the road as well as varying the size of the bottom gap between the fence and ground level. As shown in Figure D-17-2, an angular arrangement was developed for each of 3 gap sizes (no gap, 15 cm and 30 cm). Each arrangement had 5 overlapping rows of fence in such a way that the prevailing winds which would blow at right angles to these fences would be intersected by up to 5 parallel rows of fence. The objective was to observe what the resultant accumulations would be at the road adjacent to each fence configuration.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 19, 1988, a site visit was conducted to observe the above mentioned solution which had been correctly installed. Snowdrifting at the site had been limited to a single event which occurred approximately one week prior to this visit. As a

result, snow accumulations were minimal as can be observed in Figure D-17-1. Comments from Mr. Becking indicated that the road crews observed an improvement in snowdrifting conditions along the protected section of road. However, the snow measurements made did not indicate a substantial change in accumulation along the road when compared with the reference site located on Fallowfield Road to the east of the adjacent railroad tracks.

It was also noted that the field where the snowfencing was located had been ploughed and as a result of the rough terrain, the bottom gaps varied considerably. In fact, the 15 cm and 30 cm gaps appear similar. Therefore, it was recommended during the next winter than only one gap size be used.

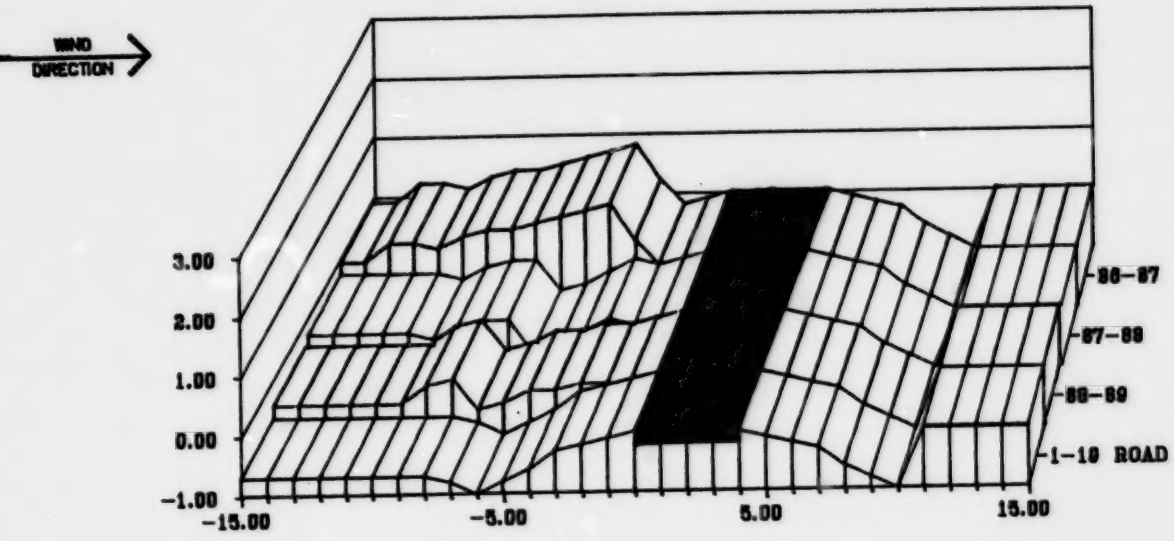
2) On March 8, 1989, another site visit was conducted to observe the revised snowfencing arrangement shown in Figure D-17-3. Similar to the previous 2 winters, the snowdrifting at this site was very minimal. Snow accumulations along the road were up to 0.5m deep and on the downwind side of the snowfences 1.0m deep.

CONCLUSIONS:

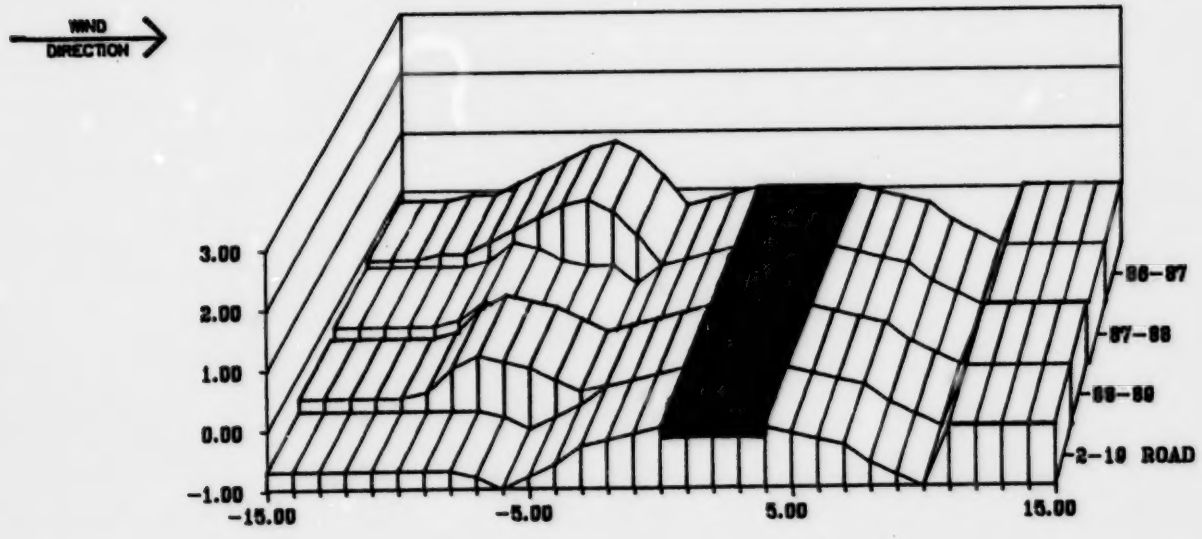
Due to the lack of snowdrifting at the site during each winter, it is difficult to draw any definite conclusions. Although it would appear that the angular type arrangement of fencing is effective in collecting snow as there were no signs of plugging or premature filling during the 2 years of observation.

RECOMMENDATIONS:

It is recommended that the Region of Ottawa-Carleton adopt an angular snowfencing pattern along the north side of Fallowfield road similar to that shown in Figure D-17-3 with the exception that only 3 effective overlapping rows of fence be installed. Details of this type of arrangement can be obtained from the manual being prepared as a companion to this report. Since this arrangement has not been fully tested, it is recommended that it be monitored until it experiences a typical winter. At that time, its continued use should be re-evaluated.



TYPICAL CROSS SECTION OF STUDY SITE



TYPICAL CROSS SECTION AT REFERENCE SITE

FIGURE D-17-1

TYPICAL SNOW ACCUMULATIONS

SITE 1-19 FALLOWFIELD ROAD, OTTAWA

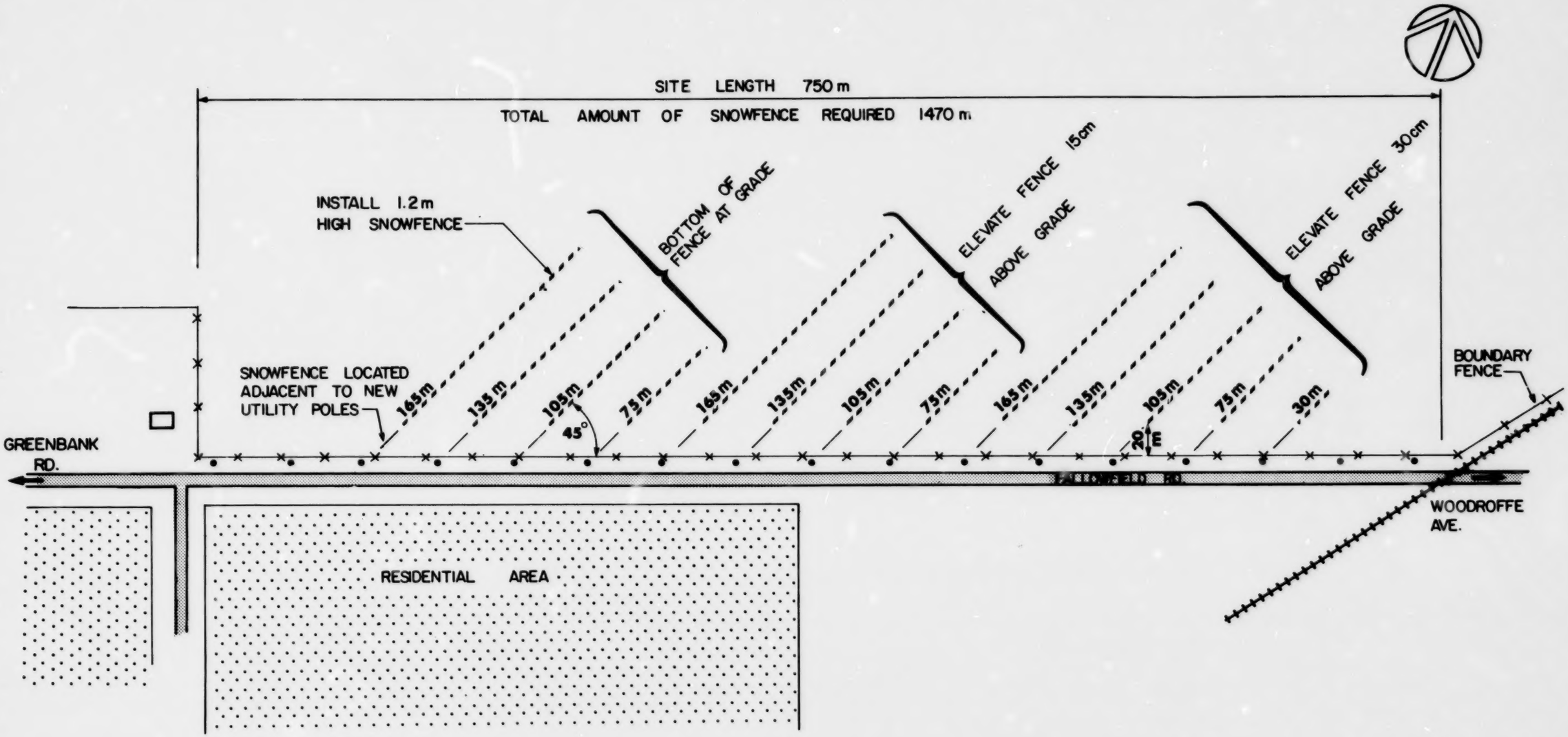


FIGURE D-17-2
RECOMMENDATIONS TO REDUCE SNOWDRIFTING
SITE 1-19 FALLOWFIELD ROAD, OTTAWA

RWDI

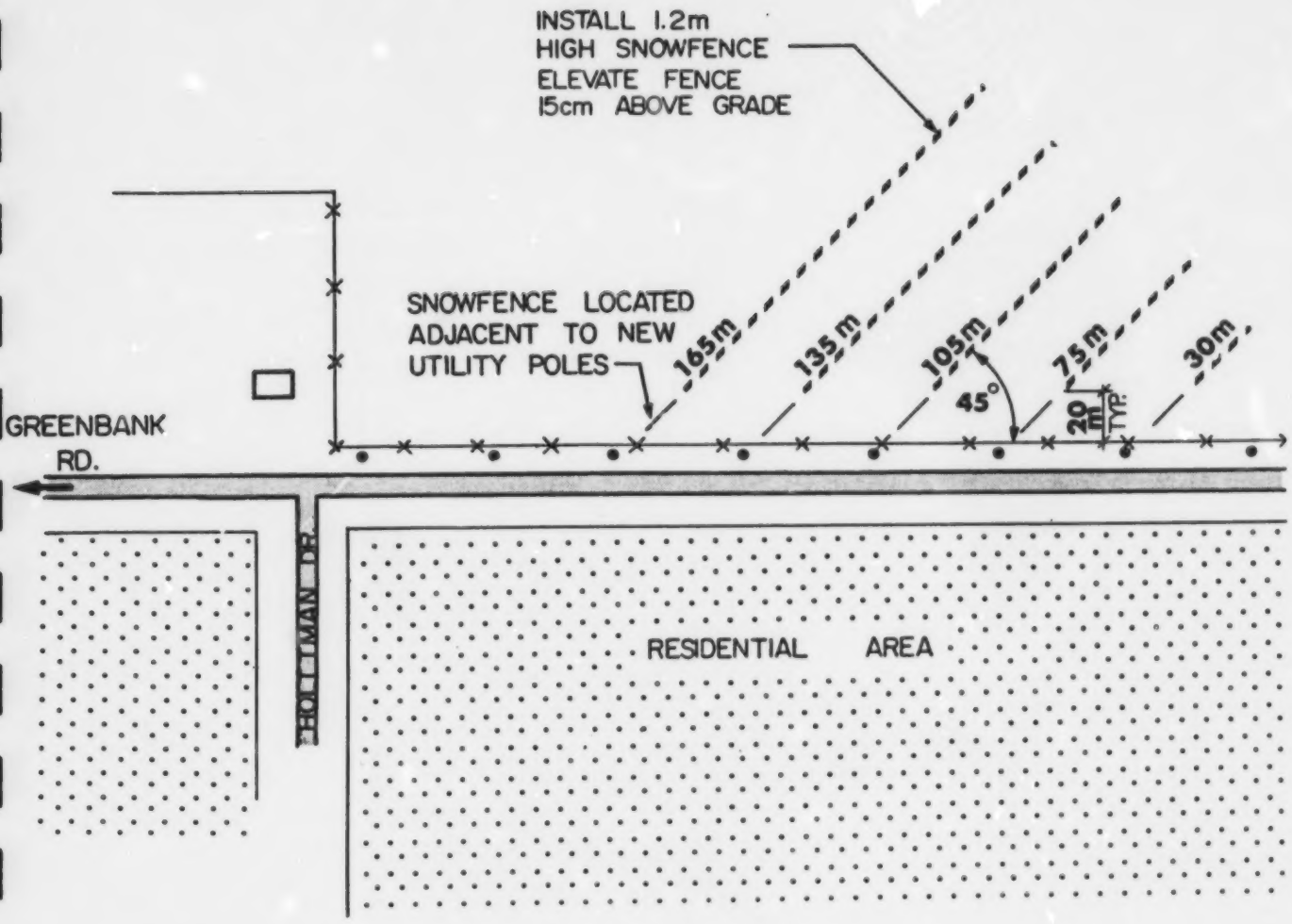


FIGURE D–17–3

REVISED RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1–19 FALLOWFIELD ROAD, OTTAWA

APPENDIX D-18

SITE SUMMARY

SITE NUMBER: 1-20

SITE NAME: Steeles Avenue

SITE LOCATION: between Conc. 5N and 5S - Milton

PROVINCE: Ontario

PRIMARY CONTACT: Brent Marshall, North District Supervisor
Regional Municipality of Halton, Milton

DESCRIPTION OF PROBLEM:

This section of road is exposed to snowdrifting problems which result in a loss of traction. Generally, the surface of the road is at approximately the same elevation as the surrounding fields, with a small ditch along both sides. The problem is not evident until the ditch fills with snow. Then the snow drifts onto the road where it sticks to the surface causing the loss of traction. To study the long term solution of elevating the road two other sites were chosen these are known as Sites 1-15 and 1-22, elevated approximately 0.5 and 1.5m respectively (Figure D-18-1).

RECOMMENDED SOLUTION:

The Region of Halton have successfully adopted a program of elevating the road above the surrounding terrain along other sections of this road and would like to continue. They are interested in determining the optimum height of fill section for a long term solution. In addition they would like to determine a temporary solution to this problem were reconstruction is not possible. To monitor the problem and develop a temporary solution this site was divided in half, the west half was left without a solution while the east half was fitted with an angular arrangement of fence as shown in Figure D-18-2. The angular arrangement was chosen because the prevailing winds which accompany blowing snow recorded at the nearby Pearson International Airport (see Appendix F) generally approach the road from a westerly direction.

PROBLEM IDENTIFICATION SITE VISIT:

The winter of 1986 - 87 did not experience the problem condition due to a lack of snow. Therefore, the problem was not observed first hand.

SOLUTION ASSESSMENT SITE VISITS:

1) The 1987-88 winter was not typical and as a result the solution did not receive a test of its effectiveness.

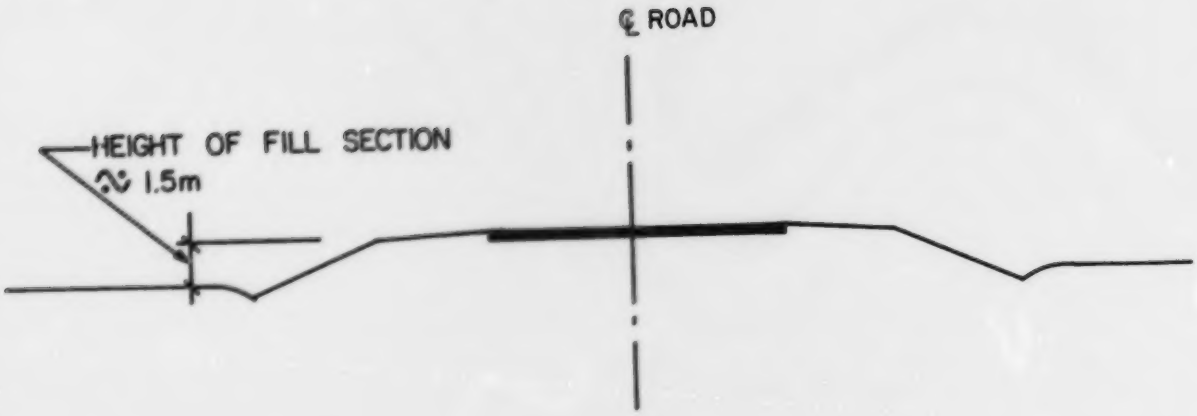
2) The 1988-89 winter was not typical either.

CONCLUSIONS:

The lack of snowfall at this site makes it impossible to draw any conclusions about the effectiveness of the solutions considered.

RECOMMENDATIONS:

If the Region of Halton is interested in continued research, they could install the snowfencing shown in Figure D-18-2 and continue to monitor its effectiveness and draw their own conclusions once the fence experiences a typical winter.



SITE 1–22
STEELES AVENUE EAST OF 10N

SITE 1–15
STEELES AVENUE BETWEEN 8N & 8S

FIGURE D–18–1
DETAILS OF ROAD CROSS SECTIONS
FOR POTENTIAL REGRADING RECOMMENDATIONS AT SITE 1–20

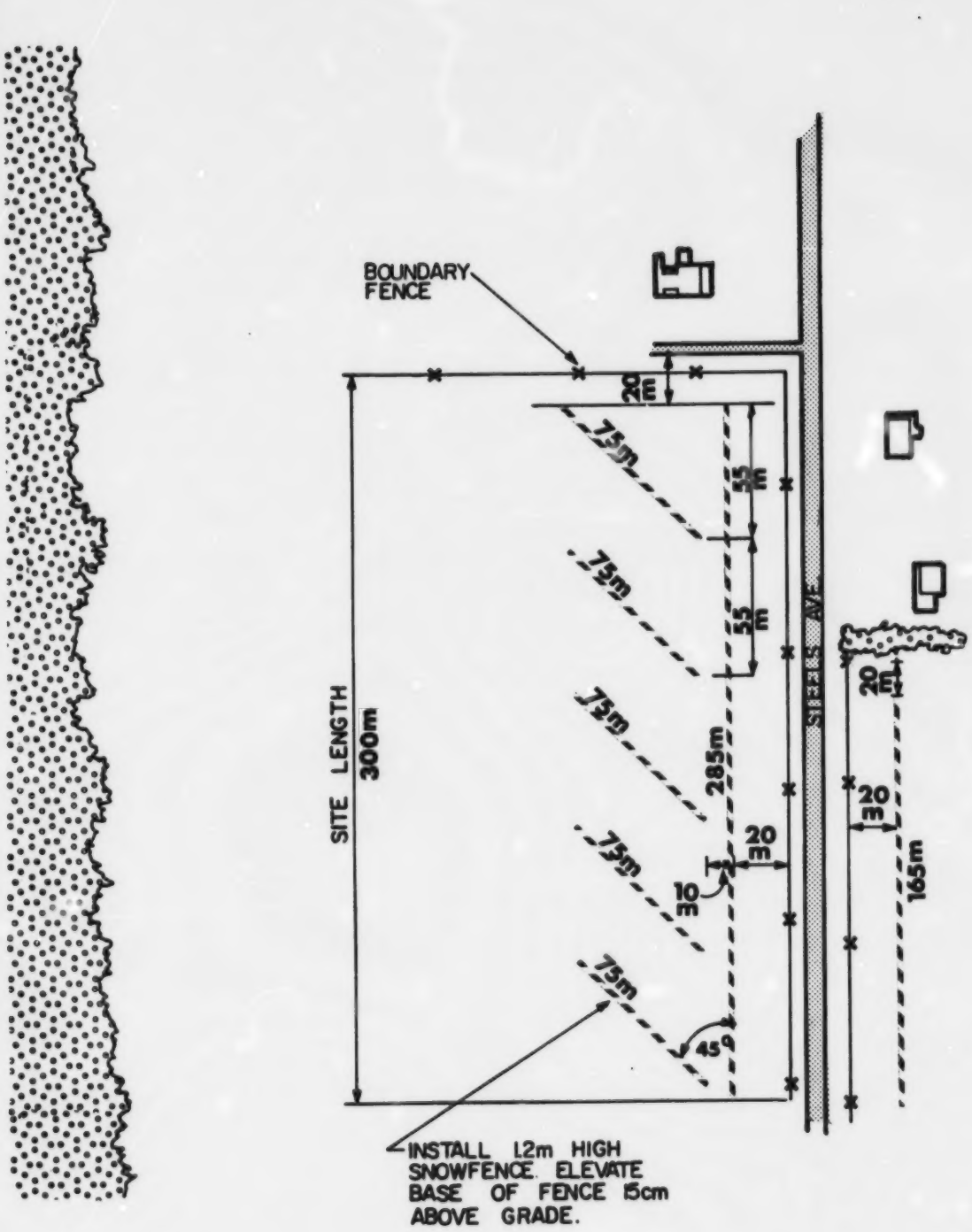


FIGURE D-18-2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1-20 STEELES AVENUE BETWEEN 5N & 5S, MILTON

APPENDIX D-19

SITE SUMMARY

SITE NUMBER: 1-23

SITE NAME: Dufferin County Road 3

SITE LOCATION: West of Orangeville

PROVINCE: Ontario

PRIMARY CONTACT: Stuart Smart - County Engineer
County of Dufferin, Orangeville

DESCRIPTION OF PROBLEM:

Snow accumulation and visibility problems occur at this site when the prevailing westerly winds blow the snow from the adjacent property into the 2-3m deep cut section where the road passes. The calm air region within the cut causes turbulence over the road which in turn results in white-out conditions and permits the snow to settle on to the road surface.

RECOMMENDED SOLUTION:

In order to solve this problem, two approaches can be taken, the first is to trap the snow upwind of the road before it enters the cut and the second is to streamline the cut to eliminate the calm air region. Since factors like cost, cooperation of the adjoining property owners and timing will affect the type of solution chosen both a temporary and a permanent solution are provided. The temporary solution will involve the use of snowfencing which is less costly and quicker to install than the permanent solution which will involve regrading the site.

The snowfencing arrangement shown in Figure D-19-1 as the temporary solution is recommended to collect the snow before it reaches the road. This arrangement has been designed to efficiently collect snow by orienting the angled sections of fence at right angles to the prevailing winds, which are predominantly from the west-northwest direction. This direction was selected after a review of wind data recorded at the Shand Dam in Fergus and at Mount Forest. Generally this data indicates that winter winds from the southwest through northwest directions are most prevalent with the west-northwest being dominant. The single row of snowfence which is parallel to the boundary fence is intended to collect the snow which drifts from the least frequent southwest direction and will not be collected by the angled snowfencing. An important detail to observe during the installation of the snowfence is to elevate it approximately 15 cm above grade. This gap permits wind to flow under the fence which will assist in preventing the fence from becoming covered with snow.

The permanent solution involves regrading the west side of the road as shown in Section X-X of Figure D-19-1. By regrading the backslope to 7:1 or less the prevailing wind will blow through the cut relatively unobstructed. Even though the cut is regraded the wind will still blow snow from the adjacent property towards the road. Therefore, it is important to eliminate any obstructions which will cause snow to accumulate on the road, in particular, plowed snow banks. As a result we have recommended that the depth of the ditch be increased to a minimum of 1.0m below the surface of the road. This enlarged ditch will provide a storage area for the plowed snow and will minimize the obstruction of the wind.

It was also observed during our site visit that an embankment exists along the east side of the road. It has been our experience that the damming effect of the wind caused by such an embankment could produce an upwind drift on the road. If this problem occurs after the regrading of the west side of the road we would recommend that the east side be regraded as shown in Section X-X of Figure D-19-1.

PROBLEM IDENTIFICATION SITE VISIT:

Since this site was added after the 1986-87 winter a problem identification site visit was not conducted. Instead meetings with Mr. Smart confirmed the above problems which results in snow accumulation of up to 3m deep in the road.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 10, 1988 a site visit was conducted to observe the effectiveness of the recommended solution. It was observed that the snowfencing solution was incorporated and that regrading was not done. The winter was less than typical with maximum accumulations measuring 1.5m or less were recorded on the upwind side of the road along with maximum accumulations of 1.2m or less on the downwind side of the snowfences. Based on information provided by Mr. Smart the snow blowing and loading costs during 1988 were the lowest since 1976 further indicating a less than typical winter.

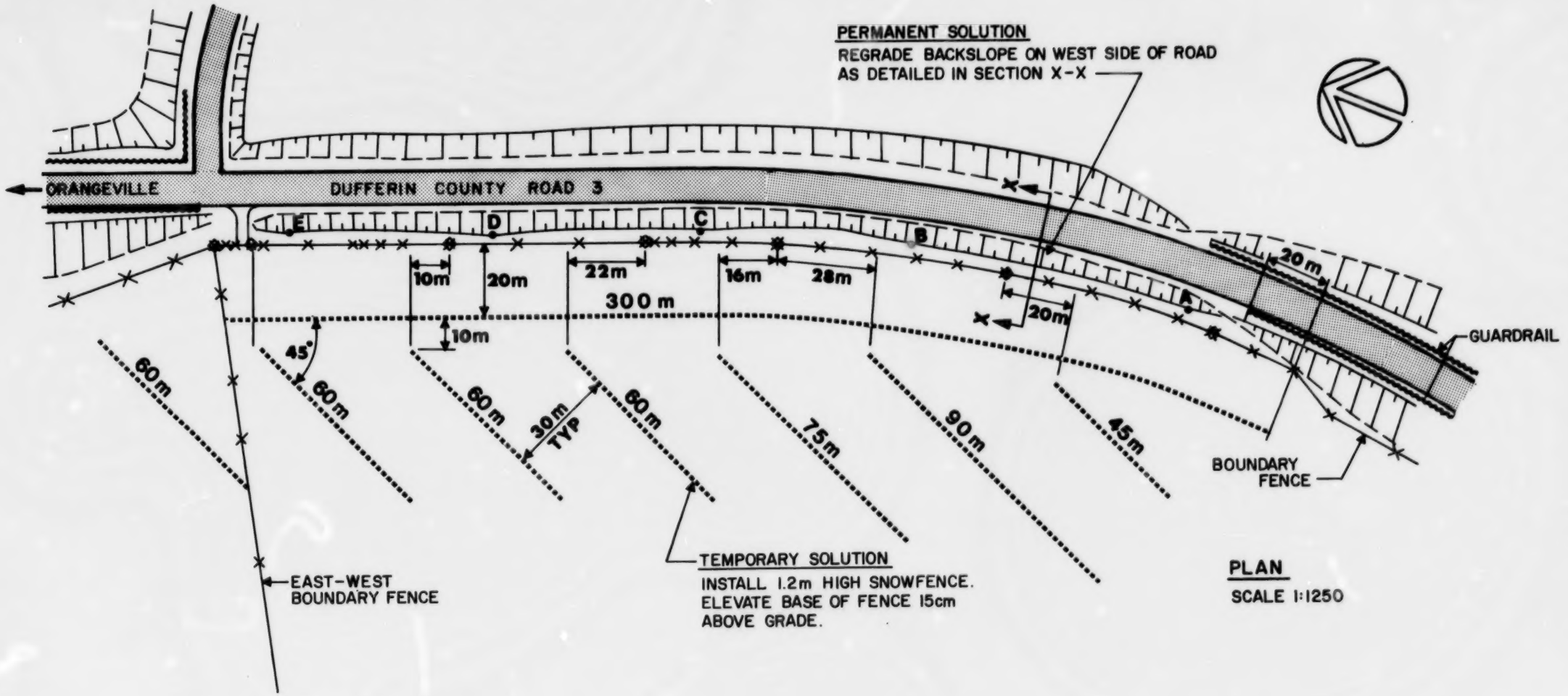
2) During the 1988-89 winter this site was observed on a number of occasions. On January 24, 1989 the maximum accumulation of approximately 0.5m deep, was observed on the downwind side of the fences. Thus, indicating another winter which experienced less than typical snowdrifting conditions.

CONCLUSIONS:

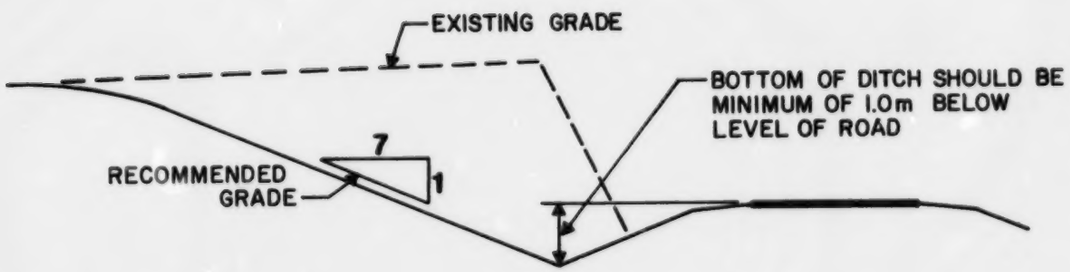
Due to the lack of snowdrifting at this site during this study the full effectiveness of the installed fencing is now known. However, based on observing the snowdrift patterns at the snowfences it would appear that the location of the snowfencing is correct.

RECOMMENDATIONS:

It is recommended that the solutions shown in Figure D-19-1 be used until a typical winter is experienced. At that time the County of Dufferin will need to assess the effectiveness of the solution and determine if alternatives are needed to improve its effectiveness.



PLAN
SCALE 1:1250



SECTION X-X
HORIZONTAL SCALE 1:300
VERTICAL SCALE 1:100

FIGURE D-19-1
RECOMMENDATIONS TO REDUCE SNOWDRIFTING
SITE 1-23 DUFFERIN COUNTY ROAD 3, ORANGEVILLE

RMDI

APPENDIX D-20

SITE SUMMARY

SITE NUMBER: 1-26

SITE NAME: Wellington County Road 18

SITE LOCATION: Elora

PROVINCE: Ontario

PRIMARY CONTACT: Bill Eggert - Assistant to County Engineer
County of Wellington, Guelph

DESCRIPTION OF PROBLEM:

Snow accumulation problems occur in the 2m deep cut at this site. The prevailing west winds blow the snow from the adjacent field which eventually collects on the road. To compound this problem the road has a narrow right-of-way which places the upwind backslope close to the highway. This location of the backslope minimizes the storage capacity for plowed snow. The County of Wellington has unsuccessfully regraded the backslope to maximize this storage capacity and would like to consider temporary snowfencing as an added solution.

RECOMMENDED SOLUTION:

Based on meteorological data collected at Waterloo Wellington Airport the angled snowfence arrangement shown in Figure D-20-1 was developed. This arrangement effectively has 3 rows of fence positioned at right angles to the prevailing wind.

PROBLEM IDENTIFICATION SITE VISIT:

Since this site was added after the 1986-87 winter the above problem conditions were not observed first hand. Instead the problem was described by Mr. Eggert and his maintenance crews.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 10, 1988 a site visit was conducted to observe the effectiveness of the installed snowfences. The lack of snowdrifting in this area has resulted in minimal accumulations. Adjacent to the highway snow accumulations measured less than 0.5m deep and adjacent to the downwind side of the fence the snow was measured to be 1.1m or less.

2) Several visits were made to the site during the 1988-89 winter, however, the lack of snow resulted in less snow accumulation than the previous winter. In fact, so little snow accumulated that measurements were not recorded.

CONCLUSIONS:

Due to the lack of snowdrifting at this site during this study the full effectiveness of the installed fencing is not known. However, based an observing the snowdrift patterns at the snowfences it would appear that their location is correct.

RECOMMENDATIONS:

It is recommended that the snowfencing layout shown in Figure D-20-1 be used until a typical winter is experienced. At that time the Wellington County Roads Department will need to assess the effectiveness of the solution and determine if alterations are needed to improve its effectiveness.

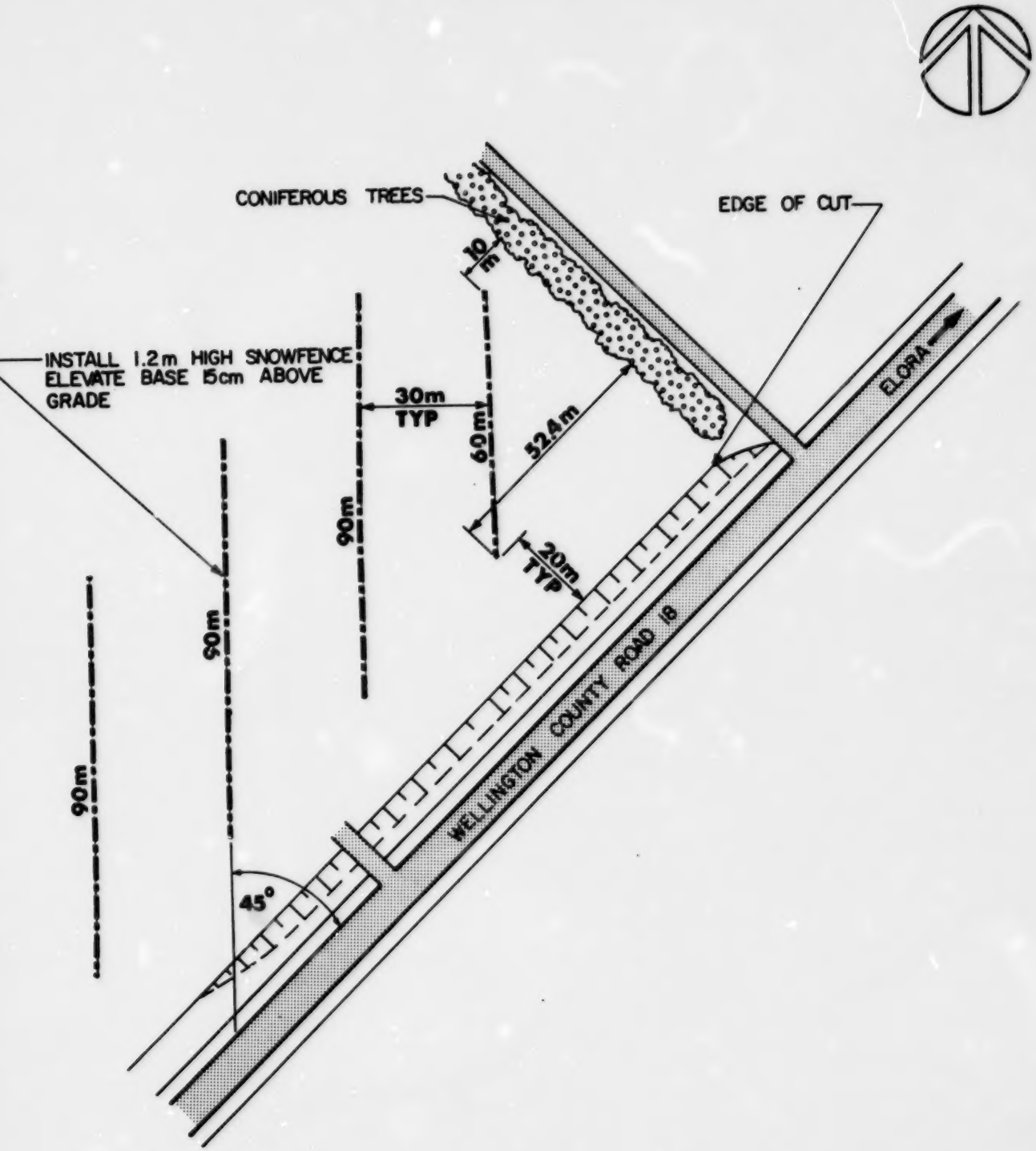


FIGURE D–20–1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1–26 WELLINGTON COUNTY ROAD 18, ELORA

APPENDIX D-21

SITE SUMMARY

SITE NUMBER: 1-27

SITE NAME: McKnight Farm

SITE LOCATION: Grey County Road 7, Meaford

PROVINCE: Ontario

PRIMARY CONTACT: Gary Shaw, Maintenance Manager
Grey County, Owen Sound

DESCRIPTION OF PROBLEM:

The road at this site is positioned in a north-south orientation and the adjacent cut section and rail fence on the west side of the road cause accumulations of up to 4m deep. As this site is representative of a number of problem locations along Grey County Road 7 in the Meaford area a successful solution at this site could be applied at all sites.

PROBLEM IDENTIFICATION SITE VISIT:

Since the site was added after the 1986-87 winter, the problem condition was not observed first hand. However, the above information provided by Mr. Shaw was confirmed by the road crew.

RECOMMENDED SOLUTION:

The current policy used by Grey County implements the use of two parallel rows of 1.2m high snowfence. Since 2.5m high snowfences are being installed at Site 1-28 which is in the same vicinity, it was decided to compare a double row of 1.2m high snowfences at this site with the 2.5m high fence at Site 1-28.

SOLUTION ASSESSMENT SITE VISITS:

1) On January 27, 1988, a site visit was conducted to assess the effectiveness of the double row of 1.2m high snowfencing. The fences had already filled with snow and accumulations of approximately 2m deep existed on the west side of the road. From the meteorological data included in Appendix F for Wiarton, it can be determined that the blowing conditions at the site are less than average along with the peak ground cover. Since these fences filled early in the winter and at the same time, the 2.5m high fences at Site 1-28 were still working, it was concluded that the taller fences would better solve the snowdrifting conditions and it was decided that 2.5m high fences would be used.

2) On February 7, 19 and March 14, 1989, separate site visits were conducted to observe the effectiveness of the 2.5m high fence which was installed as shown in Figure D-21-1. During the initial visit, snow accumulations of up to 1.5m deep were observed adjacent to the road. The fence had collected up to 1.5m of snow and was still capable of collecting more snow. The effectiveness of the solution is demonstrated in the bottom photograph in Figure D-21-2. This photograph is taken approximately 1 km south of the study site where the highway is not protected by a snowfence. Besides the obvious reduced visibility in the photograph, snow accumulations of up to 3m deep occurred.

As winter progressed, the fence at the study site continued to be successful (February 19 visit). By the final visit on March 14, 1989, the fence had nearly filled and the accumulations along the road had built up to approximately 2.5m deep while the nearby reference site had continued to have visibility problems and added accumulations.

CONCLUSIONS:

From the information gathered at this site, it can be concluded that 1.2m high fences should not be used at this site as they fill with snow too quickly. From the observations made during the 1988-89 winter, a 2.5m high fence is more appropriate since it collected more snow and therefore will be effective for larger periods of time.

RECOMMENDATIONS:

It is recommended that Grey County Roads department continue to install 2.5m high snowfences at this site and other sites along County Road 7 in this area using the details shown in Figure D-21-1.

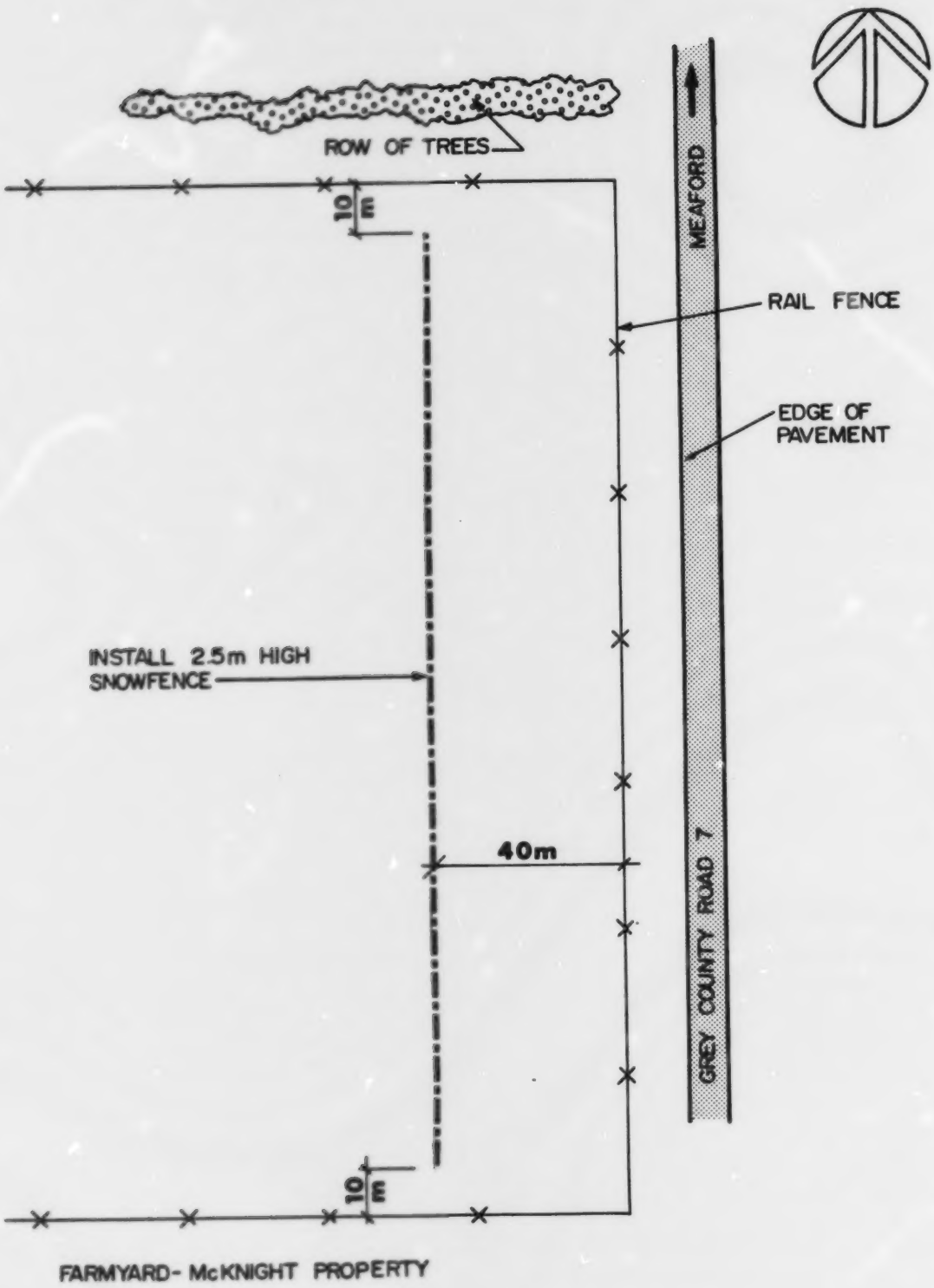


FIGURE D-21-1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1-27 McKNIGHT FARM, GREY COUNTY ROAD 7, MEAFORD

VISIBILITY AT STUDY SITE – FEBRUARY 1989

VISIBILITY AT REFERENCE SITE – FEBRUARY 1989

FIGURE D–21–2

TYPICAL SNOW ACCUMULATIONS

SITE 1–27 McKNIGHT FARM, GREY COUNTY ROAD 7, MEAFORD

APPENDIX D-22

SITE SUMMARY

SITE NUMBER: 1-28

SITE NAME: Caswell's Cut

SITE LOCATION: Grey County Road 4, Meaford

PROVINCE; Ontario

PRIMARY CONTACT: Gary Shaw, Maintenance Manager
Grey County, Owen Sound

DESCRIPTION OF PROBLEM:

The road at this site is positioned in an east-west orientation. The prevailing southwest through northwest winds deposit snow in a 2 - 3m deep rock cut. During a typical winter this cut has drifted full, frequently necessitating the use of a snowblower to clear the snow.

PROBLEM IDENTIFICATION SITE VISIT:

Since this site was added after the 1986-87 winter, the problem conditions were not observed first hand. However, Mr. Shaw indicates that the cut typically drifts in similar to the problem condition shown in the road cross section illustrated in Figure D-22-1.

RECOMMENDED SOLUTION:

From meteorological data collected at Wiarton Airport, a 2.5m high fence layout was developed for this site as shown in Figure D-22-2. Since the prevailing winds were from the southwest through northwest, two angled fences were used to protect for the southwest winds from the south side of the road and for the northwest winds from the north side of the road. Since the Grey County Roads Department had not installed 2.5m high fences before it was decided to use U channel sign posts spaced 2 - 3m apart to support the fence.

SOLUTION ASSESSMENT SITE VISITS:

1) On January 27, 1988, a site visit was conducted to assess the effectiveness of the installed solution (Figure D-22-2). It was observed that the cut was practically clear of snow and the fence on the south side of the road had accumulated snow measuring up to 2.5m deep (see Figure D-22-1). However, the fence on the north side of the road had plugged with snow rendering it ineffective. Observation of the blowing snow wind directions for Wiarton Airport in Appendix F indicates that the frequency of the 1987-88 winds is similar to the long term mean. Therefore, it was concluded that

snowdrifting was typical and the fence on the south side of the road was not needed. Two subsequent visits conducted later in the winter indicated that these wind directions were still frequent and that the snowfence on the north side of the road eventually filled. The areas at both ends of the cut began to fill with snow and it was obvious that additional snowfencing would be needed on the south side of the road. Prior to the next winter, a revised layout was developed as shown in Figure D-22-3. In mid-April 1988, a site visit was conducted to observe the effects of melt water as the snow accumulations at the snowfence receded. It was observed that the snow accumulations had melted away but no soil erosion was apparent.

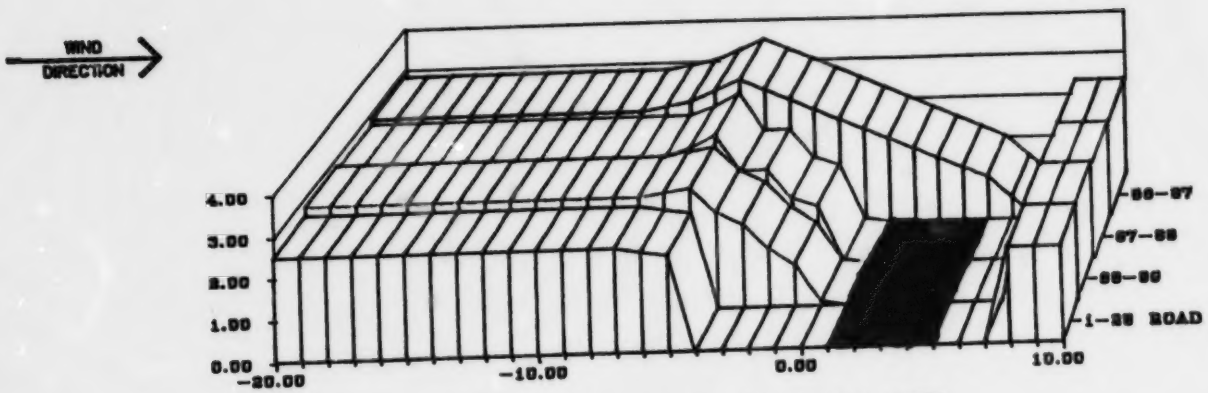
2) During the 1988-89 winter, three site visits were conducted to observe the effectiveness of the revised snowfence layout. These visits were conducted on February 7, 19 and March 14, 1989. In each case, the 3 fences on the south side of the road were accumulating snow effectively with maximum depths of up to 1.8m recorded. The added snowfences were effective as the snow accumulations that occurred the previous winter at the ends of the cut were reduced.

CONCLUSIONS:

Even though the snow conditions during the study winters (1987-88 and 1988-89) were slightly below average, the 2.5m high snowfences were effective in reducing snow accumulations on the road at the study site particularly when the revised layout was used. These taller than average fences did not create soil erosion problems during the spring run off of the melt water. In addition, the U channel sign posts used to support the fence offered adequate resistance to the wind forces and were not blown over.

RECOMMENDATIONS:

It is recommended that the Grey County Roads department continue to use the revised 2.5m high snowfence layout as shown in Figure D-22-3 using U channel sign posts to support the fence.



TYPICAL CROSS SECTION AT STUDY SITE

STUDY SITE FEBRUARY 1989

TYPICAL SNOWFENCE FEBRUARY 1989

FIGURE D-22-1

TYPICAL SNOW ACCUMULATIONS

SITE 1-28 CASWELL'S CUT, GREY COUNTY ROAD 4, MEAFORD

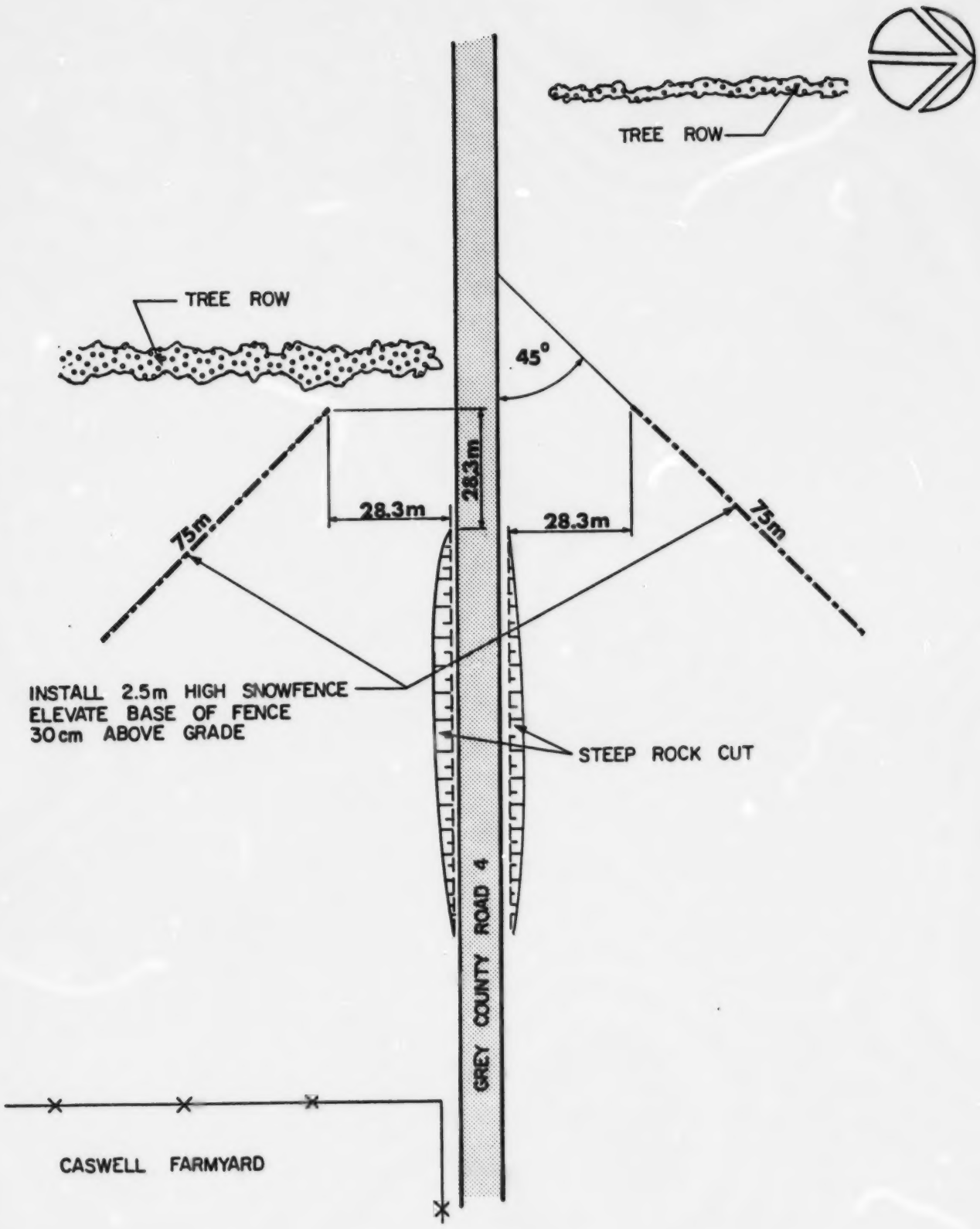


FIGURE D–22–2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1–28 CASWELL'S CUT, GREY COUNTY ROAD 4, MEAFORD

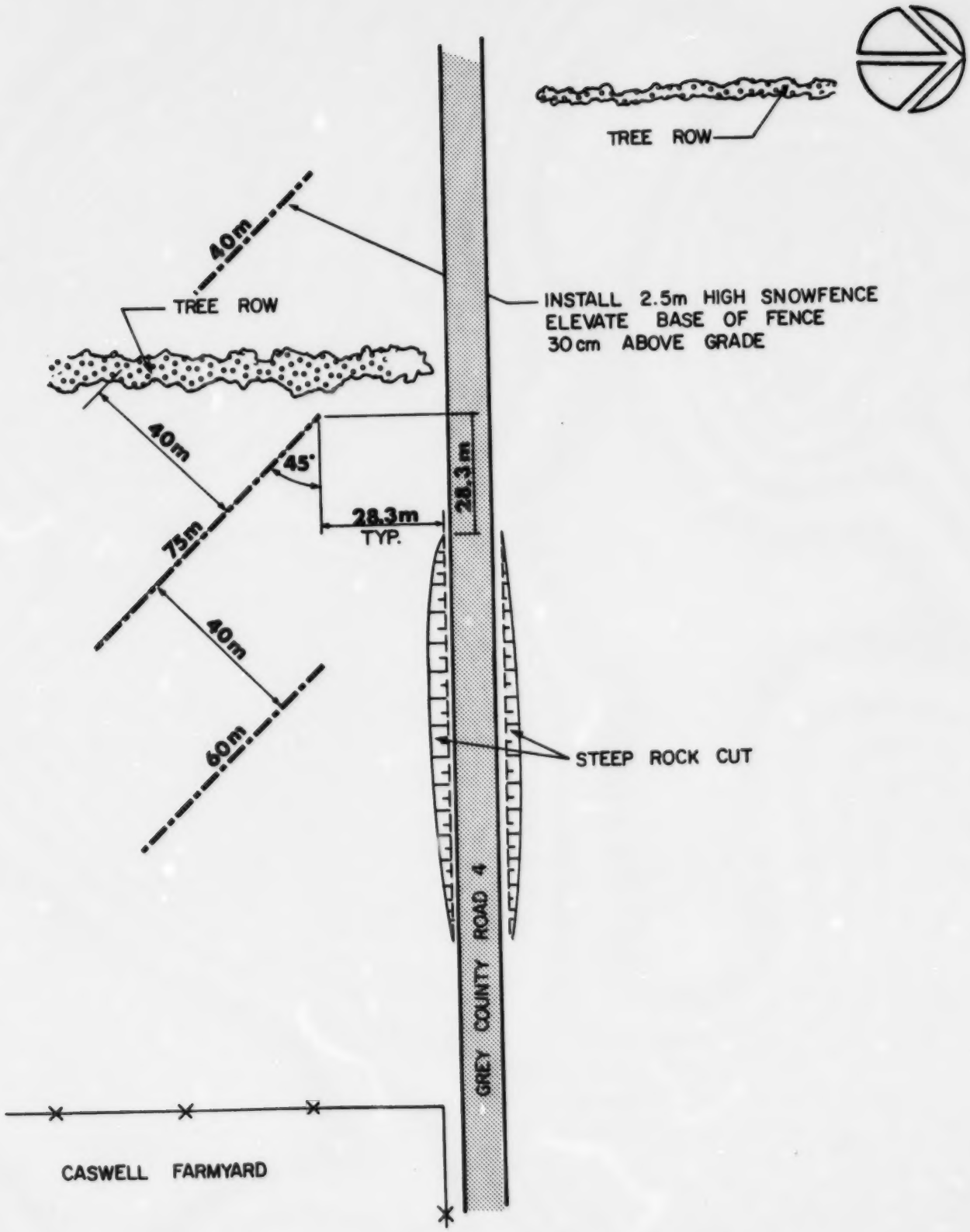


FIGURE D–22–3

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 1–28 CASWELL'S CUT, GREY COUNTY ROAD 4, MEAFORD

APPENDIX D-23

SITE SUMMARY

SITE NUMBER: 3-6

SITE NAME: Route 55

SITE LOCATION: Interchange of Route 108, Sherbrooke

PROVINCE: Quebec

PRIMARY CONTACT: Alain Labonte
Transport Quebec, Quebec City

DESCRIPTION OF PROBLEM:

At this site, the snow blows off an adjacent farm into a cut section where the exit ramp is located. The snow frequently accumulates to a depth of 1.0m or more. Since the land in this area is under cultivation, it is likely that temporary snowfencing is the only workable solution.

PROBLEM IDENTIFICATION SITE VISIT:

On March 18, 1987, a site visit was conducted to view the above mentioned problem condition. The accumulations in the adjacent field measured 0.5m deep with the plowed accumulations measuring up to 1.6m. Discussions with the maintenance staff indicated that this site was not a serious problem this winter. It was agreed that snowfencing would be the solution to be used.

RECOMMENDED SOLUTION:

Meteorological data recorded at Sherbrooke Airport indicates that west winds prevail in this area. As a result, a 2.5m high fence was recommended to be installed along the west side of the ramp as shown in Figure D-23-1.

SOLUTION ASSESSMENT SITE VISITS:

1) On March 9, 1989, site visits were conducted to assess the recommended solutions. It was observed that the fence was installed as 145m long, the east half of the fence was 2.5m high and the west half was 1.2m. In addition, the top half of the 2.5m fence had fallen off the posts for the majority of its length. Although there was snow collected on the downwind side of the fence, as expected, there was not a noticeable improvement in the snow accumulations along the road when compared to other unprotected areas of the ramp. Similar to the previous winter, the 1987-88 winter was not severe. The measured accumulations in the open field were 0.3m deep which is about half of the previous winter.

2) This site was not studied during the 1988-89 winter.

CONCLUSIONS:

Although the accumulations on the downwind side of the fence measured in the 1987-88 winter indicate that the placement of the fence was relatively correct, the winter was not severe enough to determine if the fence could effectively collect snow.

RECOMMENDATIONS:

The Quebec Ministry of Transport should continue to install the recommended solution shown in Figure D-23-1 and monitor it until it experiences a typical winter. At that time, the effectiveness of the solution should be assessed and its continued use decided either in its present or revised configuration. It is also recommended that improved installation methods be used to insure that the fence does not blow over in the future. A companion manual has been proposed which outlines these methods.

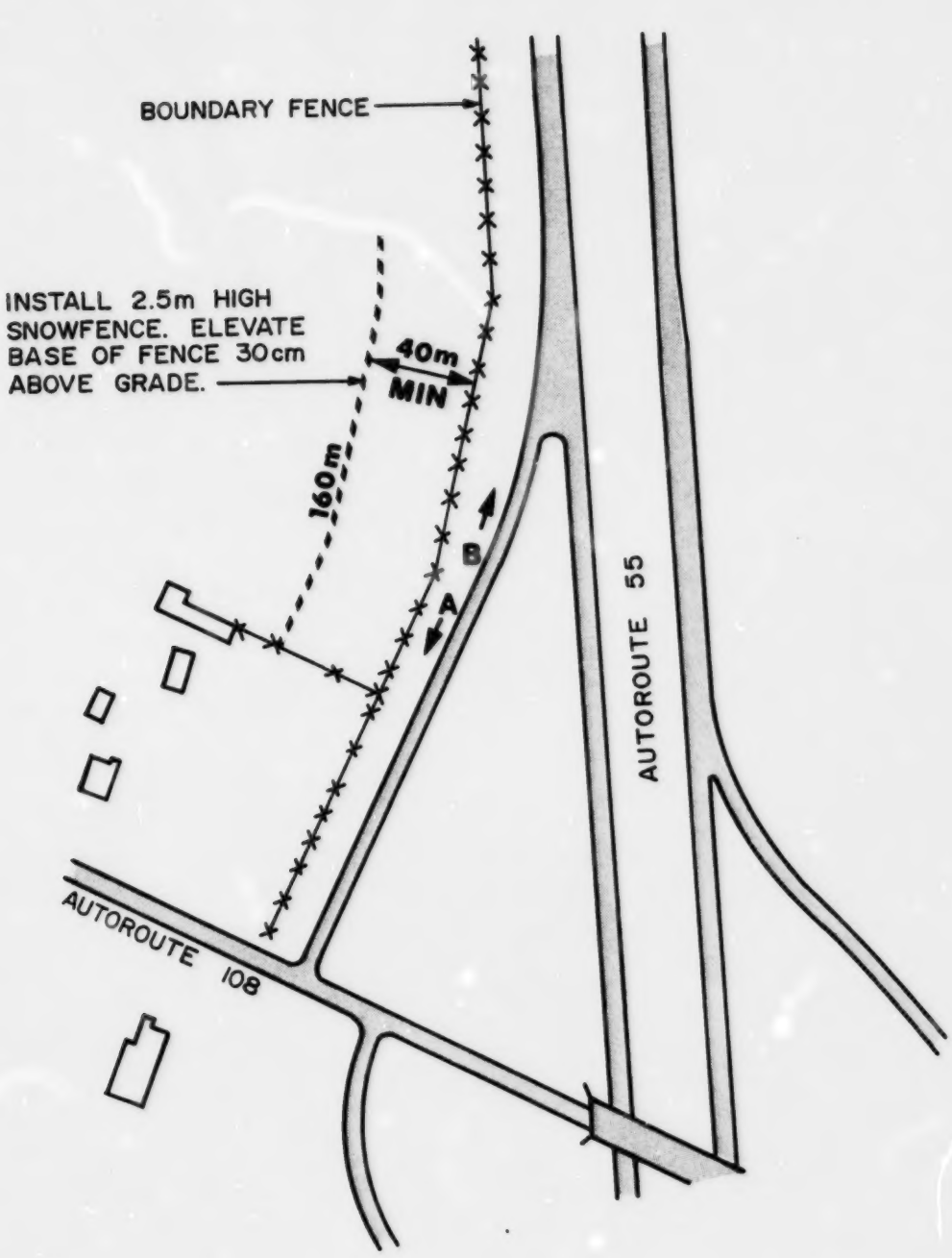


FIGURE D-23-1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 3-6 INTERCHANGE AT AUTOROUTE 55 AND 108

APPENDIX D-24

SITE SUMMARY

SITE NUMBER: 3-11

SITE NAME: Route 20

SITE LOCATION: East of Route 132 - La Pocatiere

PROVINCE: Quebec

PRIMARY CONTACT: Alain LaBonte
Transport Quebec, Quebec City

DESCRIPTION OF PROBLEM:

Route 20 at this site is oriented in a southeast by northwest direction. The westerly winds which accompany the snowdrifting problems at this site are impeded by large mounds of stockpiled top soil and shrubs. These obstructions frequently cause visibility problems over the highway surface.

PROBLEM IDENTIFICATION SITE VISIT:

On March 25, 1987, a site visit was conducted to observe the problem conditions. Even though the snow cover had melted away, the residual snow accumulation adjacent to the stock piled topsoil and shrubs located upwind of the road (see Figure D-24-1) was indicative of the prevailing wind direction and the accumulation problem. Although not observed first hand at this site, visibility problems have been observed at other locations, when similar obstructions are located upwind of the road.

RECOMMENDED SOLUTION:

After discussions with Transport Quebec, it was agreed that the shrubs and topsoil as located in Figure D-24-2 would be removed.

SOLUTION ASSESSMENT SITE VISITS:

1) On March 10, 1988, a site visit was conducted to assess the effectiveness of the recommended solutions. It was observed that most of the shrubs were removed; however, the topsoil was not. Due to a communication problem, topsoil was removed at another site approximately one kilometer away. Discussions with the maintenance supervisor and observations at the site indicated that the removal of the shrubs reduced snow accumulations adjacent to the road. At the locations where the topsoil stockpile was removed, the visibility problems were improved as reported by the maintenance crew.

2) Due to a reduced number of study sites during the 1988-89 winter, this site was not included.

CONCLUSIONS:

Although there was limited data collected at the site, it can be concluded that removing the obstructions reduced snow accumulations and improved visibility at the highway. In addition, it can be concluded that clear instructions are needed to be given to field crews prior to implementing a solution to insure that the work is carried out properly.

RECOMMENDATIONS:

The removal of the stockpiled topsoil to the level of the surrounding terrain is recommended at this site. In addition, regular maintenance at this site should include removal of shrubs which occur on the highway right-of-way.

STOCKPILED TOPSOIL UPWIND OF ROAD

SHRUBS UPWIND OF ROAD

FIGURE D-24-1

TYPICAL SNOW ACCUMULATION

SITE 3-11 AUTOROUTE 20 AT LA POCATIERE

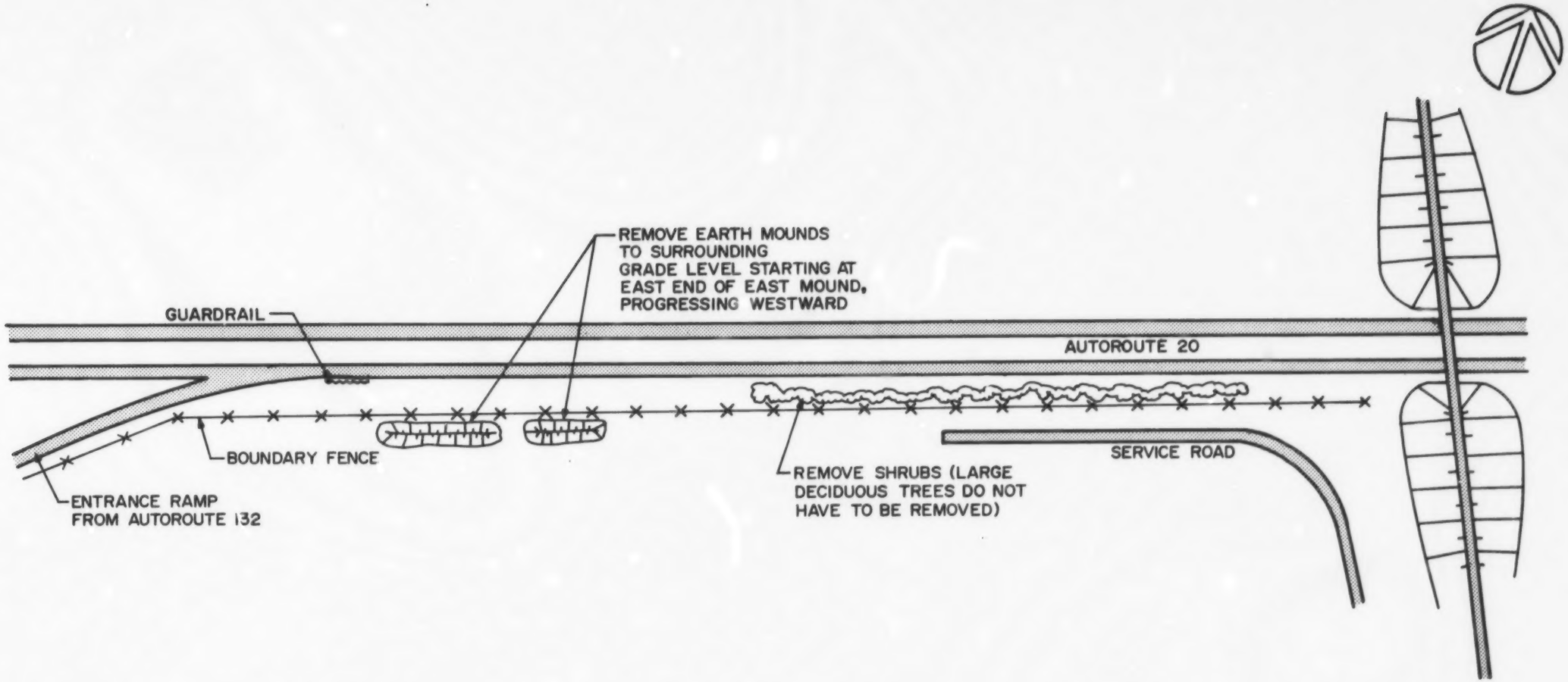


FIGURE D-24-2
RECOMMENDATIONS TO REDUCE SNOWDRIFTING
SITE 3-11 AUTOROUTE 20 AT LA POCATIERE

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APPENDIX D-25

SITE SUMMARY

SITE NUMBER: 5-3

SITE NAME: Dempster Highway (Big Cut)

SITE LOCATION: Km 4.0 Northwest Territories

PRIMARY CONTACTS: John Bunge
Government of the NWT Highways Dept., Yellowknife, NWT

Art Barnes, Supervisor
Government of the NWT Highways Dept.,
Inuvik, NWT

DESCRIPTION OF PROBLEM:

This site has a cut section approximately 350m long and up to 15m deep. A model study of this site conducted by the authors in 1978 confirmed the snow was drifting from the northwest direction and would virtually fill the cut. Regrading the cut and installing a permanent snowfence erected on a berm was recommended. Some regrading was completed, however, the snowfence and berm were not installed. The regrading appears to have improved the initial problem but significant snow accumulations still exist. Art Barnes has had 1.2m high snowfencing installed but it does not have enough capacity to significantly improve conditions. As well, the winds which regularly exceed 100 km/h destroy this fencing.

PROBLEM IDENTIFICATION SITE VISIT:

On March 10, 1987 a site visit was conducted to view the above mentioned problem conditions. The 1.2m high snowfences which were installed were filled with snow and some were destroyed due to the high wind speeds in this area. Although not shown photographically, snow accumulations exceeding 3m deep were observed adjacent to the road at this site. It was agreed by the NWT Highways Department that a taller and stronger fence would be needed to collect the snow upwind of the site.

RECOMMENDED SOLUTION:

As shown in Figure D-25-3, a 4.3m (14 ft) high Wyoming type fence was recommended to control snowdrifting at this site.

SOLUTION ASSESSMENT SITE VISITS:

1) Due to the uncertainty of the wind (specific loading) at this location, as a result of its remote location from any weather stations, it was decided that 2 small test sections would be installed to determine if they could withstand the wind loading. Each section

of fence was approximately 15m long, one was 2.75m (9 ft) high while the second was 4.3m (16 ft) high. Each section of fence was anchored with 6-3/4" reinforcing bars driven into the rock. On March 19, 1988, a site visit was conducted to assess the ability of each fence section to withstand the wind loading. The anchor attachment to the fence failed, permitting both fences to blow over. The reinforcing bars were simply driven through a pipe bolted to the fence base. Since the reinforcing bars and pipes were not physically attached the overturning moment caused by the wind pulled the pipe over the reinforcing bar and a failure resulted.

2) During the summer of 1988, approximately 350m of 4.3m high fencing was installed, south of the creek as shown in Figure D-25-3. On March 29, 1989, a site visit was conducted to view the installation. Even after severe wind conditions, the fence was still standing. The success was the result of welding the reinforcing bar and pipe connection together (see Figure D-25-2). The fence was only 1/2 full (i.e. maximum snowdrift depth was approximately 2m) and the drift extended 80 - 85m downwind from the fence. The resultant snow accumulations in the cut at the road were less than 2m deep (Figure D-25-2). In comparison, a nearby cut experienced accumulation of up to 7m deep during the same winter (see Reference Location Figure D-25-1).

   The only problem was that approximately 10m of fence blew over. The fence failure resulted from the cracking of the lower horizontal member (Figure D-25-3). This cracking was observed at a number of similar locations along the entire length of the fence and will require modification to ensure that future failures do not occur.

CONCLUSIONS:

It can be concluded that this type of snowfence installation is well suited for this kind of site where the ground will not easily permit posts to be put in the ground yet a tall fence is required.

RECOMMENDATIONS:

It is recommended that the snowfencing arrangement which was recently installed be used in the future. In addition, it is recommended that a timber design specialist be consulted in order to strengthen the lower horizontal member of the fence. Finally the snowdrifting conditions at the north end of the cut should be monitored and if snowdrifting problems occur consideration should be given to extending the fence north of the creek. An opening will be required for the creek to pass through. This opening should be sufficient to prevent significant accumulations to block the creek which could cause flooding during spring run off.

STUDY SITE

REFERENCE SITE

FIGURE D–25–1
TYPICAL SNOW ACCUMULATIONS
SITE 5–3 DEMPSTER HIGHWAY KM 4.0

4.3m HIGH WYOMING TYPE SNOWFENCE

WELDED CONNECTION

CRACKED HORIZONTAL MEMBER

FIGURE D–25–2

SNOWFENCE DETAILS

SITE 5–3 DEMPSTER HIGHWAY, KM 4.0

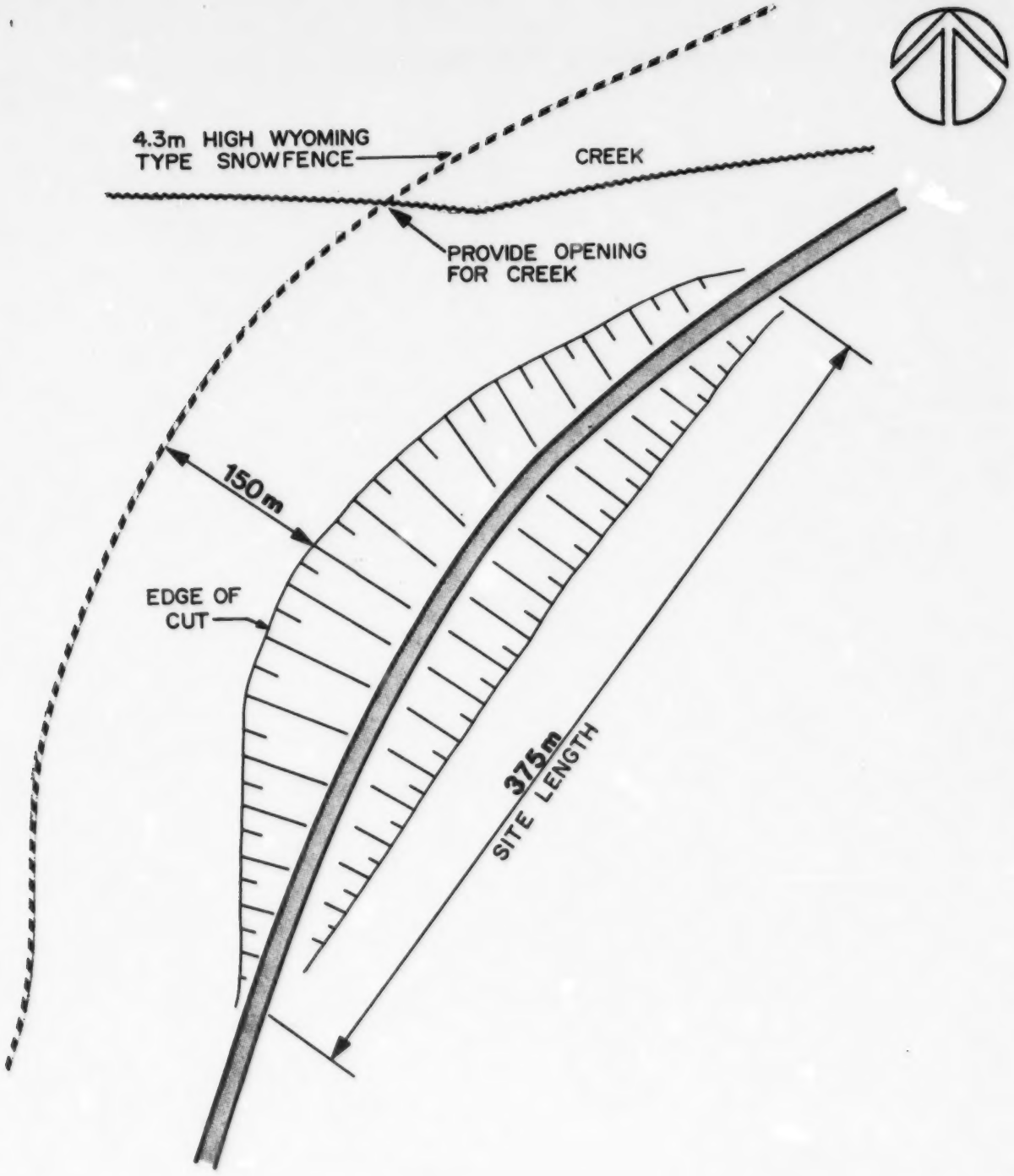


FIGURE D–25–3

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 5–3 DEMPSTER HIGHWAY, KM 4.0

APPENDIX D-26

SITE SUMMARY

SITE NUMBER: 5-4

SITE NAME: Dempster Highway

SITE LOCATION: Km 28.5, Northwest Territories

PRIMARY CONTACTS: John Bunge
Government of NWT Highways Dept.
Yellowknife, NWT

Art Barnes, Supervisor
Government of NWT Highways Dept.,
Inuvik, NWT

DESCRIPTION OF PROBLEM:

A cut section was created at this site to permit the highway to pass through a long slender ridge. The prevailing winds cause snow to accumulate in this cut. The possibility of regrading the cut was discussed with Art Barnes. He was in favour of this solution because fill material is needed for another site nearby, as well as solving this problem.

PROBLEM IDENTIFICATION SITE VISIT:

On March 10, 1987, a site visit was conducted to observe the problem condition. As shown in the upper photograph in Figure D-26-1, snow accumulations occur along both sides of the road adjacent to the cut sections. It should also be noted that the winter in this area was less than the typical.

RECOMMENDED SOLUTION:

As shown in Figure D-26-2, it was recommended that the cut be regraded to increase the shoulder width and to reduce the backslope to 7:1 or less.

SOLUTION ASSESSMENT SITE VISITS:

1) Since the solution was not implemented during the summer of 1988, the first and only solution assessment site visit was conducted on March 29, 1989. As shown in the lower photograph in Figure D-26-1, the regrading was completed and the snow accumulations were greatly reduced. It was noted that severe snowdrifting conditions occurred during this winter but only small accumulations resulted at this site. At nearby sites, snow accumulations of up to 7m deep observed during this same winter (see lower photograph Figure D-25-1).

CONCLUSIONS:

Based on the observations made at this site, regrading the backslope of the cut to 7:1 or less was adequate to alleviate snowdrifting problems associated with severe storm conditions.

RECOMMENDATIONS:

Continued use of the regrading details shown in Figure D-26-2 is recommended at this site and any site which experiences similar problems.

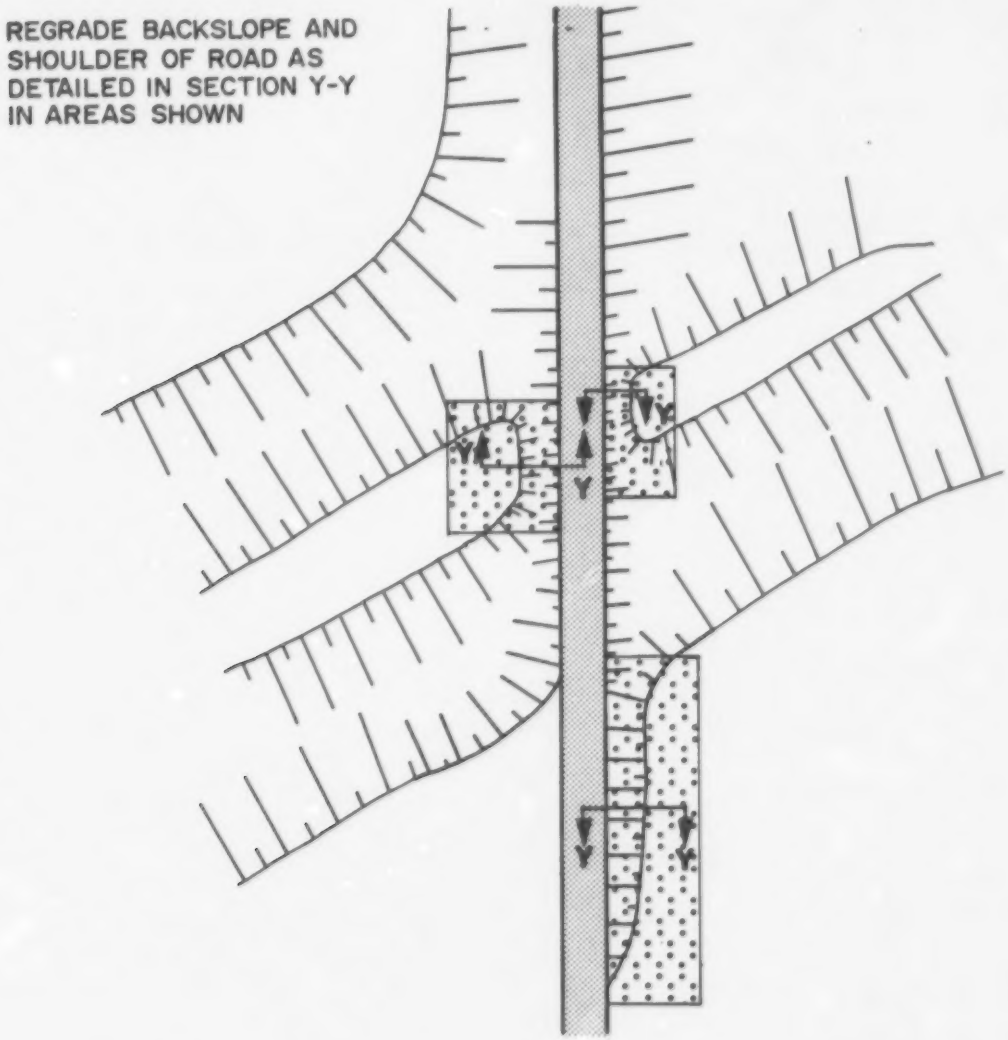
PROBLEM: 1986–87 WINTER

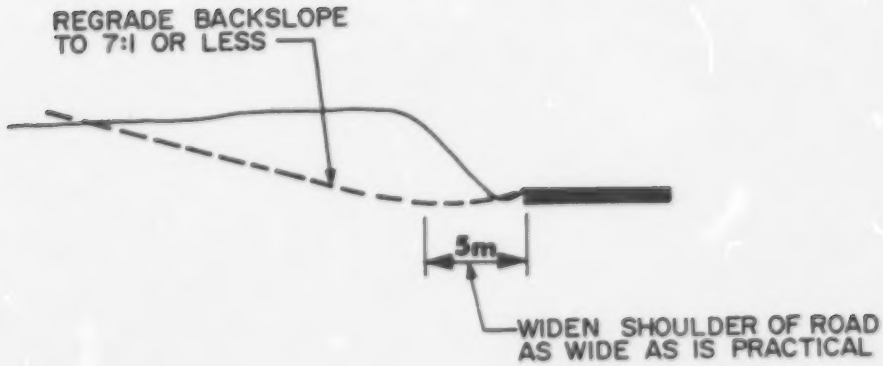
SOLUTION: 1988–89 WINTER

FIGURE D–26–.

TYPICAL SNOW ACCUMULATIONS

SITE 5–4 DEMPSTER HIGHWAY KM 28.5





SECTION Y-Y

FIGURE D-26-2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 5-4 DEMPSTER HIGHWAY KM 28.5

APPENDIX D-27

SITE SUMMARY

SITE NUMBER: 7-1

SITE NAME: Dempster Highway

SITE LOCATION: Km 265, Yukon Territory

PRIMARY CONTACT: Robin Walsh, Yukon Highways Department, Whitehorse, Yukon Territory

DESCRIPTION OF PROBLEM:

This site has a single cut located on the west side of a superelevated road section which is generally oriented in a north-south direction. The prevailing east winds blow up over a small ridge on the east side of the road. The winds deposit the snow on the upwind side of the cut directly on the road. Some regrading of the cut was done; more is required.

PROBLEM IDENTIFICATION SITE VISIT:

On March 11, 1987, a site visit was conducted to view the problem condition. Similar to the upper photograph in Figure D-27-1, snow accumulations of 2.0m were observed on the downwind side of the road. Since the backslope is close to the edge of the road, the snow cannot be easily ploughed off the road. In addition, the inclined surface of the superelevated road accumulates snow on the downwind side of the road.

RECOMMENDED SOLUTION:

As shown in Figures D-27-2 and D-27-3, regrading the road was recommended along with a 1.2m high snowfence adjacent to the east side of the road. The snowfence will collect the snow before it passes over the road while the regrading will streamline the cut and a wider shoulder permits more room to store ploughed snow.

SOLUTION ASSESSMENT SITE VISITS:

1) On March 19, 1988, a site visit was conducted to assess the effectiveness of the installed solutions. It was observed that the regrading was completed which also included increasing the road profile by approximately 0.5m. However, only the south half of the snowfence was installed. As shown in Figure D-27-1, the area of the road protected by the snowfence reduced snow accumulations of less than 1.0m while the unprotected section has accumulations which exceed 2.0m.

2) On March 28, 1989, a second solution assessment site visit was conducted. It was observed that the balance of the snowfence (not installed the previous winter) had been erected. The fence, however, was located approximately 6m west of the crest of the

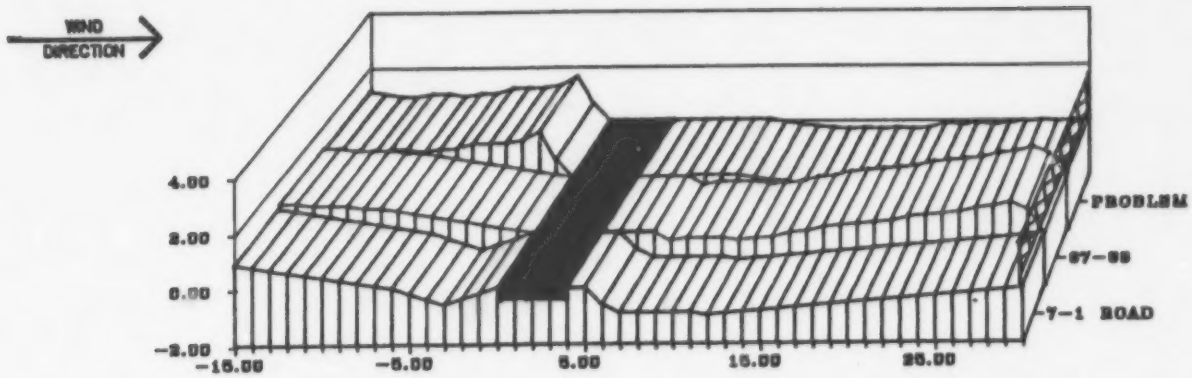
ridge. When the wind blows over the ridge, a separated flow region occurs in the vicinity of the fence, causing the fence to bury the snow. Even though the fence was not working efficiently, the maximum accumulations measured less than 0.5m deep on the downwind side of the road.

CONCLUSIONS:

It can be concluded from our observations that the snowfence is required to make the regrading solutions effective.

RECOMMENDATIONS:

The continued use of the solutions shown in Figure D-27-2 and D-27-3 are recommended.



TYPICAL CROSS SECTION AT STUDY SITE

WITHOUT SNOWFENCE (1987-88)

WITH SNOWFENCE (1987-88)

FIGURE D-27-1
TYPICAL SNOW ACCUMULATIONS
SITE 7-1 DEMPSTER HIGHWAY 265.0

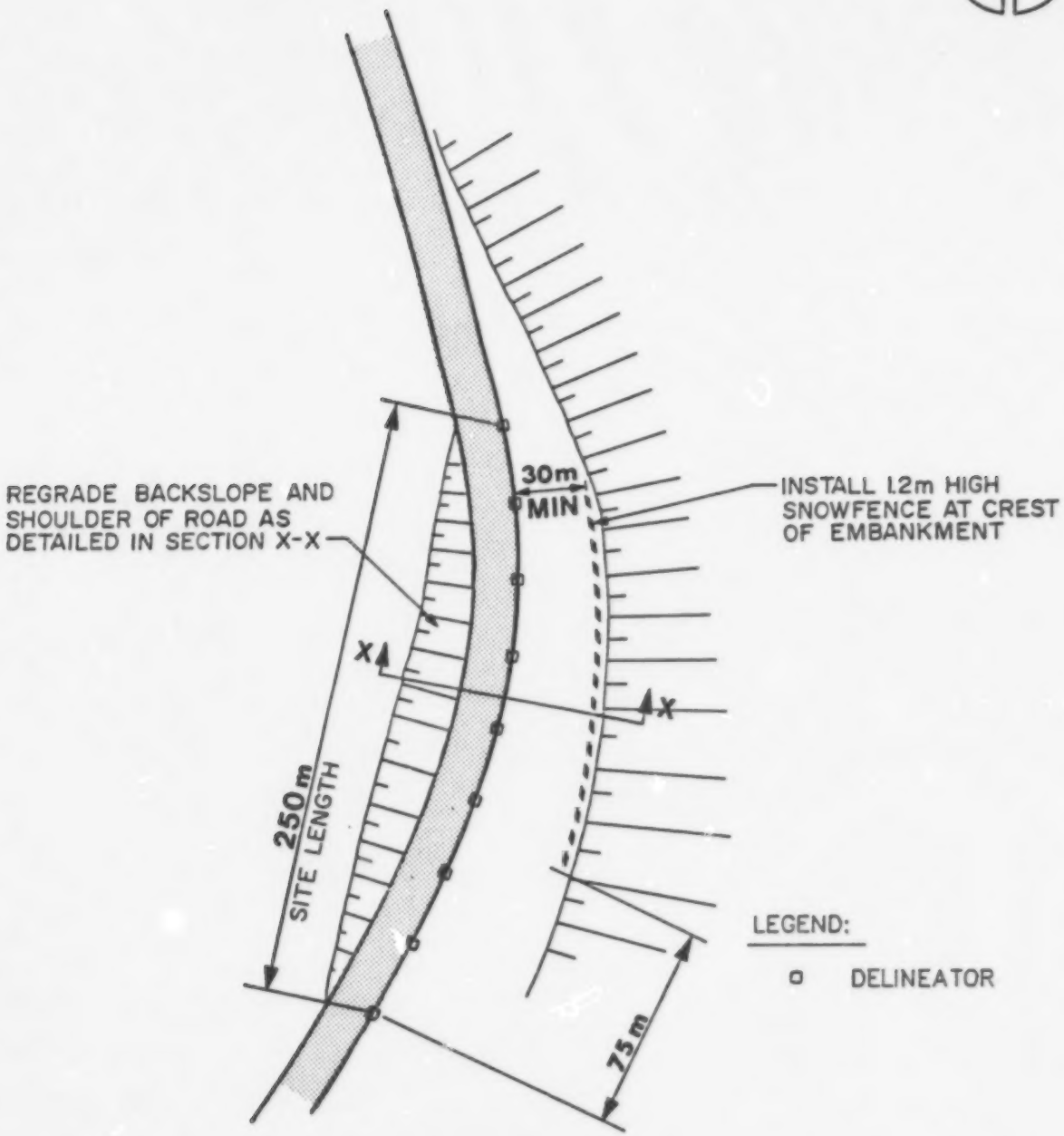
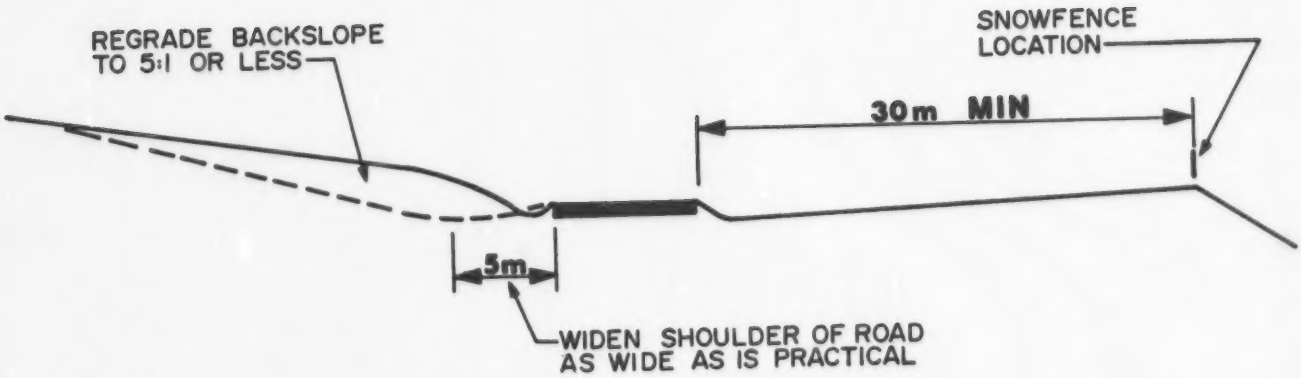


FIGURE D-27-2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 7-1 DEMPSTER HIGHWAY, KM 265.0



SECTION X-X

FIGURE D-27-3

DETAILS OF RECOMMENDED SOLUTIONS

SITE 7-1 DEMPSTER HIGHWAY, KM 265.0

APPENDIX D-28

SITE SUMMARY

SITE NUMBER: 7-2

SITE NAME: Dempster Highway

SITE LOCATION: Km 106, Yukon Territory

PRIMARY CONTACT: Robin Walsh, Yukon Highways Department, Whitehorse, Yukon Territory

DESCRIPTION OF PROBLEM:

At this site, the highway is generally oriented in a north-northeast by south-southwest direction. A row of 2-3m high shrubs are located along the east side of the highway which cause snow accumulations on the highway for the prevailing east winds.

PROBLEM IDENTIFICATION SITE VISIT:

On March 11, 1989, a site visit was conducted to observe the above mentioned problem conditions. The resultant ploughed snow bank was greater than 2.5m high on the upwind side of the road. The removal of these shrubs was discussed with the Yukon Highways Department as the appropriate solution.

RECOMMENDED SOLUTION:

As shown in Figure D-28-1 the removal of the shrubs along both sides of the highway was recommended.

SOLUTION ASSESSMENT SITE VISITS:

1) On March 19, 1988 and March 28, 1989, two separate site visits were conducted to view the effectiveness of removing these shrubs. The resultant snowbanks along the highway at this site were observed as being 1.0m or less except where for convenience a bulldozer was used to push the snow back in a larger 1.0 - 1.5m high bank. This practise is not recommended since the plowed banks replace the obstruction caused by the previously removed trees. Instead the snow should be moved to the west side of the road which is also the downwind side. There still exists a small cut midway along the site and is causing some of the accumulations at the highway.

CONCLUSIONS:

The removal of the shrubs reduced the resultant accumulations at this site.

RECOMMENDATIONS:

The removal of similar shrubs along the balance of the Dempster Highway is recommended. Particularly, where the shrubs are also exposed to open terrain upwind of the site.

At this particular site, some regrading is recommended to remove a small cut midway along the site.

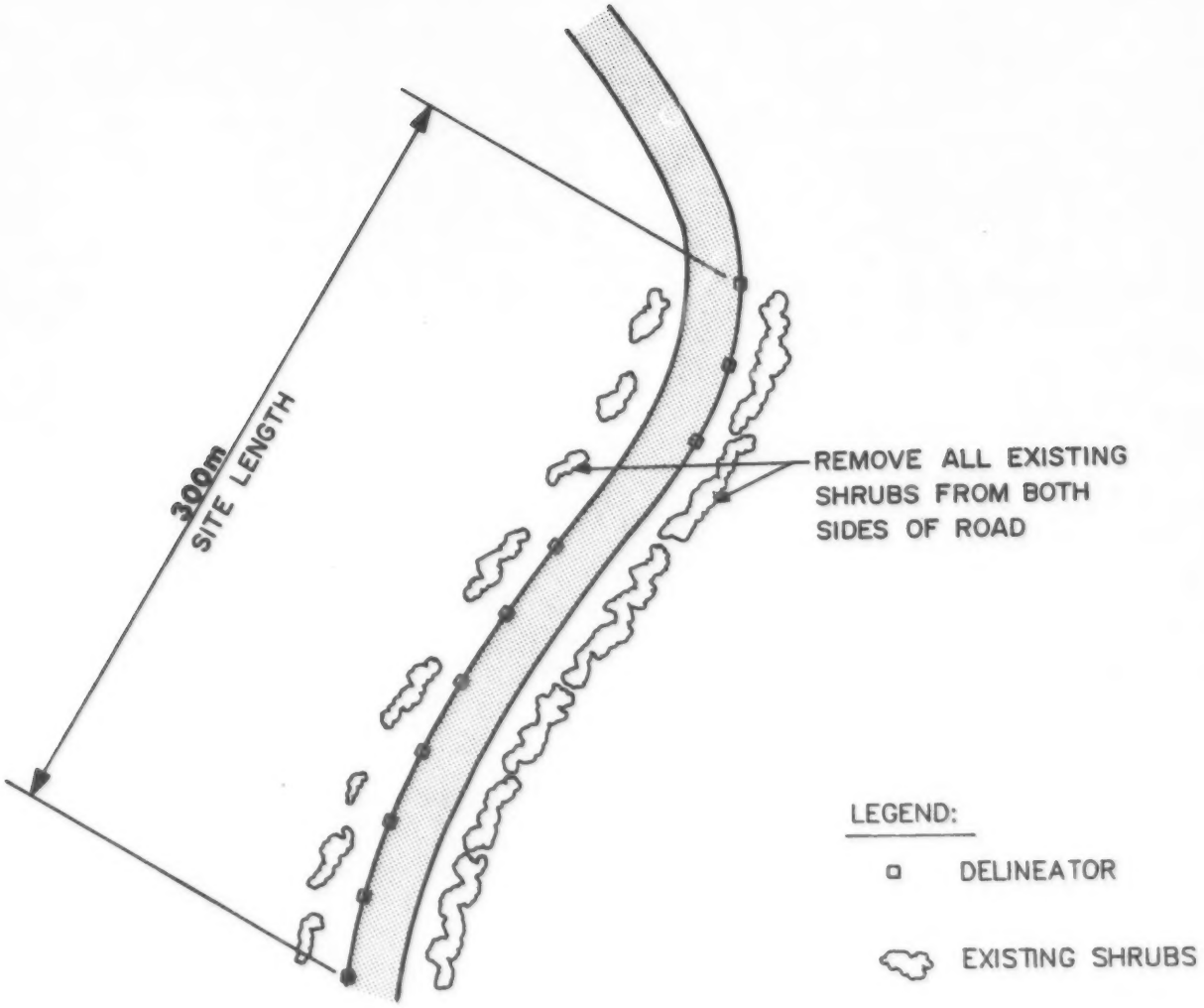


FIGURE D-28-1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 7-2 DEMPSTER HIGHWAY, KM 106.0

APPENDIX D-29

SITE SUMMARY

SITE NUMBER: 9-1

SITE NAME: Trans Canada Highway

SITE LOCATION: South of Palmer Road, Woodstock

PROVINCE; New Brunswick

PRIMARY CONTACT: Clive Wood
New Brunswick, Department of Transport
Fredericton

DESCRIPTION OF PROBLEM:

The highway at this site is on a fill section located in a bend in the road. The prevailing westerly winds at this site scour snow from the adjacent fields and deposits it on the highway causing traction problems.

PROBLEM IDENTIFICATION SITE VISIT:

Since this site was added after the 1986-87 winter, the traction problems were not observed at the site. However, during the solution assessment site visit during the 1987-88 winter, the snow was adhering to the road to the north of the site were the highway was not protected by the recommended fence.

RECOMMENDED SOLUTION:

Meteorological data gathered at the Fredericton Airport was used to develop the snowfencing arrangement shown in Figure D-29-1. Essentially, the snowfence is designed to collect the snow before it can drift onto the road.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 22, 1988, a site visit was conducted to observe the effectiveness of the installed solution. As shown in the cross section in Figure D-29-2, the problem condition to the north of the site shows plowed snow banks adjacent to the road. However, when the snowfence is added the snowbanks are reduced which means less snow is being blown towards the road and then being plowed into a bank alongside the highway.

2) On March 1, 1989, a second solution assessment site visit was conducted with similar observations to those made the previous year.

CONCLUSIONS:

From Appendix F peak snow cover at Fredericton Airport was slightly below 4 year return value of 82 cm for 1987-88 (69 cm) while 1988-89 was considerably lower (28 cm). Therefore the 1987-88 results can be considered as representative of a significant winter from a snow drifting view point. It would appear that the fence is effective in reducing the volume of drifted snow approaching the road.

RECOMMENDATION:

It is recommended that the snowfencing arrangement shown in Figure D-22-1 be used in the future. However, it may be advisable to observe road conditions immediately north and south of the snowfence because conditions observed recently indicate that the fence may need to be extended to protect these areas.

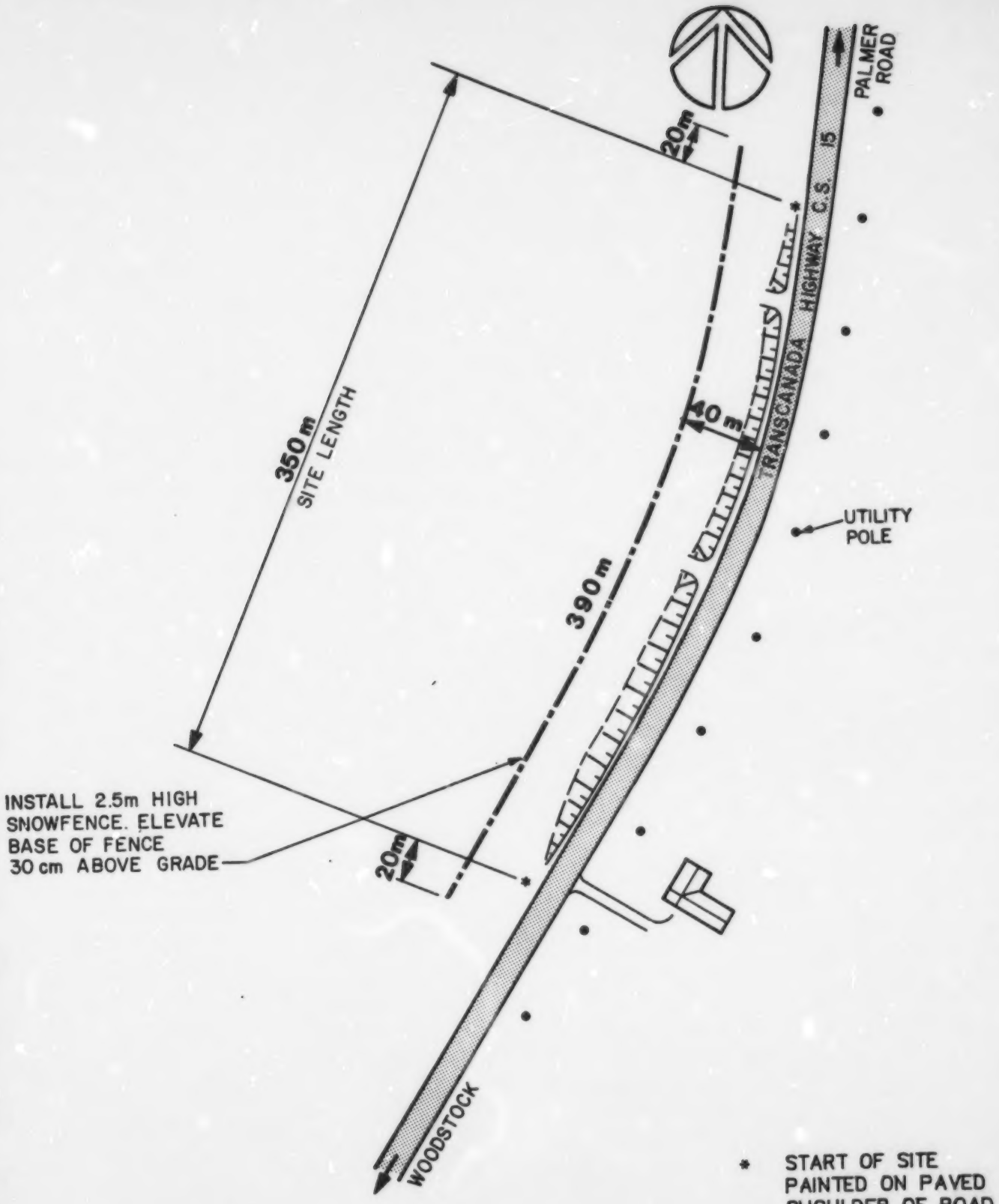
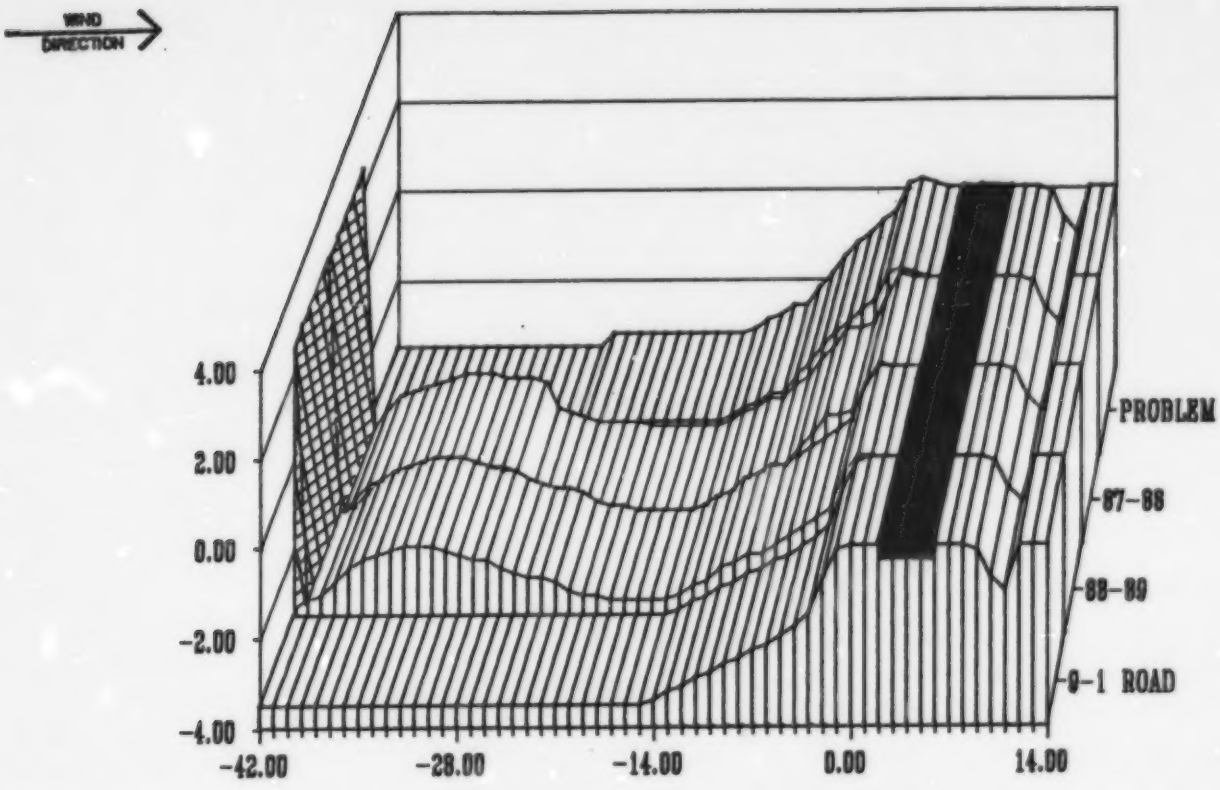


FIGURE D–29–1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING
SITE 9–1 T.C.H. SOUTH OF PALMER ROAD, WOODSTOCK



TYPICAL CROSS SECTION AT STUDY SITE

FIGURE D-29-2

TYPICAL SNOW ACCUMULATIONS

SITE 9-1 T.C.H. SOUTH OF PALMER ROAD, WOODSTOCK

APPENDIX D-30

SITE SUMMARY

SITE NUMBER: 9-2

SITE NAME: Trans Canada Highway

SITE LOCATION: Waterville

PROVINCE; New Brunswick

PRIMARY CONTACT: Clive Wood
New Brunswick, Department of Transport
Fredericton

DESCRIPTION OF PROBLEM:

The highway at this location is oriented in a north-northeast by south-southwest direction and has a 1-2m deep cut section along the west side of the road. The prevailing westerly winds drift snow into the cut which accumulates on the highway. Combined with the plowed snowbanks, these accumulations are often 3m deep.

PROBLEM IDENTIFICATION SITE VISIT:

The addition of this site after the 1986-87 winter did not permit the observation of the problem first hand. The above problem was described by local field crews. However, during the 1987-88 winter, a gap was left in the recommended fence installation which resulted in a condition which resembled the problem (see upper photograph in Figure D-30-1). This accumulation measured up to 2.0m deep.

RECOMMENDED SOLUTION:

In an attempt to collect the snow upwind of the road, a 2.5m high snowfence layout was recommended as shown in Figure D-30-2.

SOLUTION ASSESSMENT SITE VISIT:

1) On February 22, 1988, a site visit was conducted to assess the effectiveness of the installed solution. The fence was installed correctly but the gap left between the north end of the fence and the barn permitted snow to blow towards the highway and accumulate in the cut (see upper photograph, and cross section in Figure D-30-1). However, along the balance of the site, accumulations adjacent to the road were recorded as less than 1.5m with the majority of the accumulation caused by the adjacent ditch (see lower photograph Figure D-30-1).

2) On March 1, 1989, another solution assessment site visit was conducted. The revised snowfence arrangement shown in Figure D-30-3 was installed which included a 90m

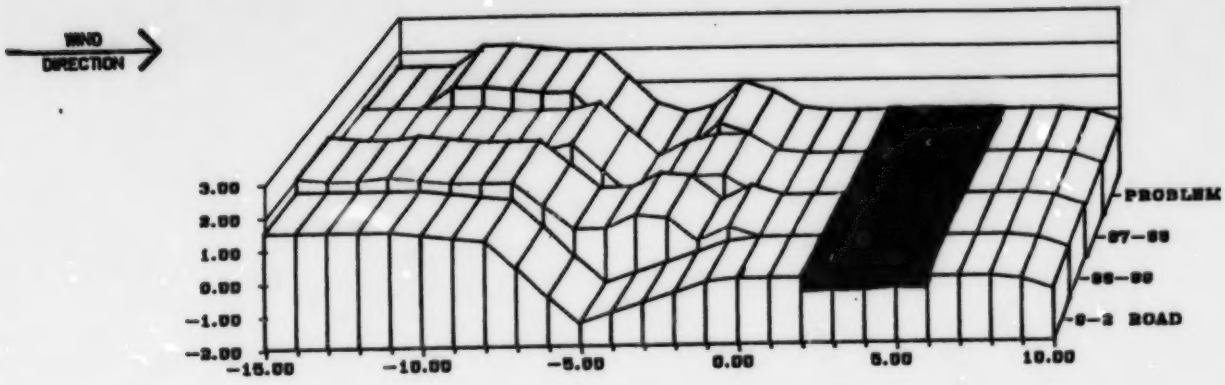
section of the fence to protect the gap which facilitates vehicular movement between the north end of the fence and the barn. The winter was less severe than the previous winter but the solution was still working. Snow accumulations up to 1.7m were recorded adjacent to the fence while accumulations adjacent to the road measured 1.2m or less.

CONCLUSIONS:

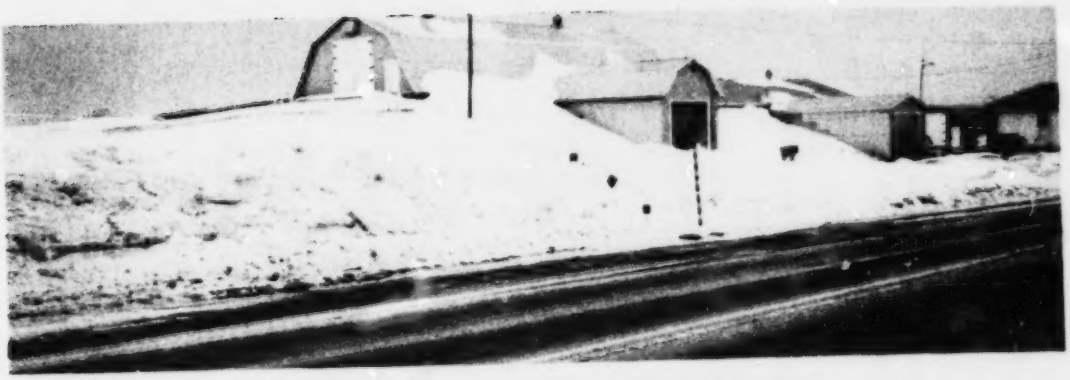
Based on the 1987-88 winter which was slightly less than average (Appendix F - Fredericton Airport) this 2.5m high snowfence was working effectively which improved when the revised solution was installed during 1988-89 winter. Comments from the field crew indicate that this snowfence greatly improved conditions at this site.

RECOMMENDATIONS:

It is recommended that the revised snowfence arrangement (Figure D-30-3) be used in the future. The 90m section might need to be extended in the future to protect the gap between the barn shown on the drawing and the next building to the north (based on comments received from the road crew on March 1, 1989).



TYPICAL CROSS SECTION AT STUDY SITE



WITHOUT SNOWFENCE FEBRUARY 1988

WITH SNOWFENCE FEBRUARY 1988

FIGURE D-30-1

TYPICAL SNOW ACCUMULATIONS

SITE 9-2 TRANSCANADA HIGHWAY, WATERVILLE

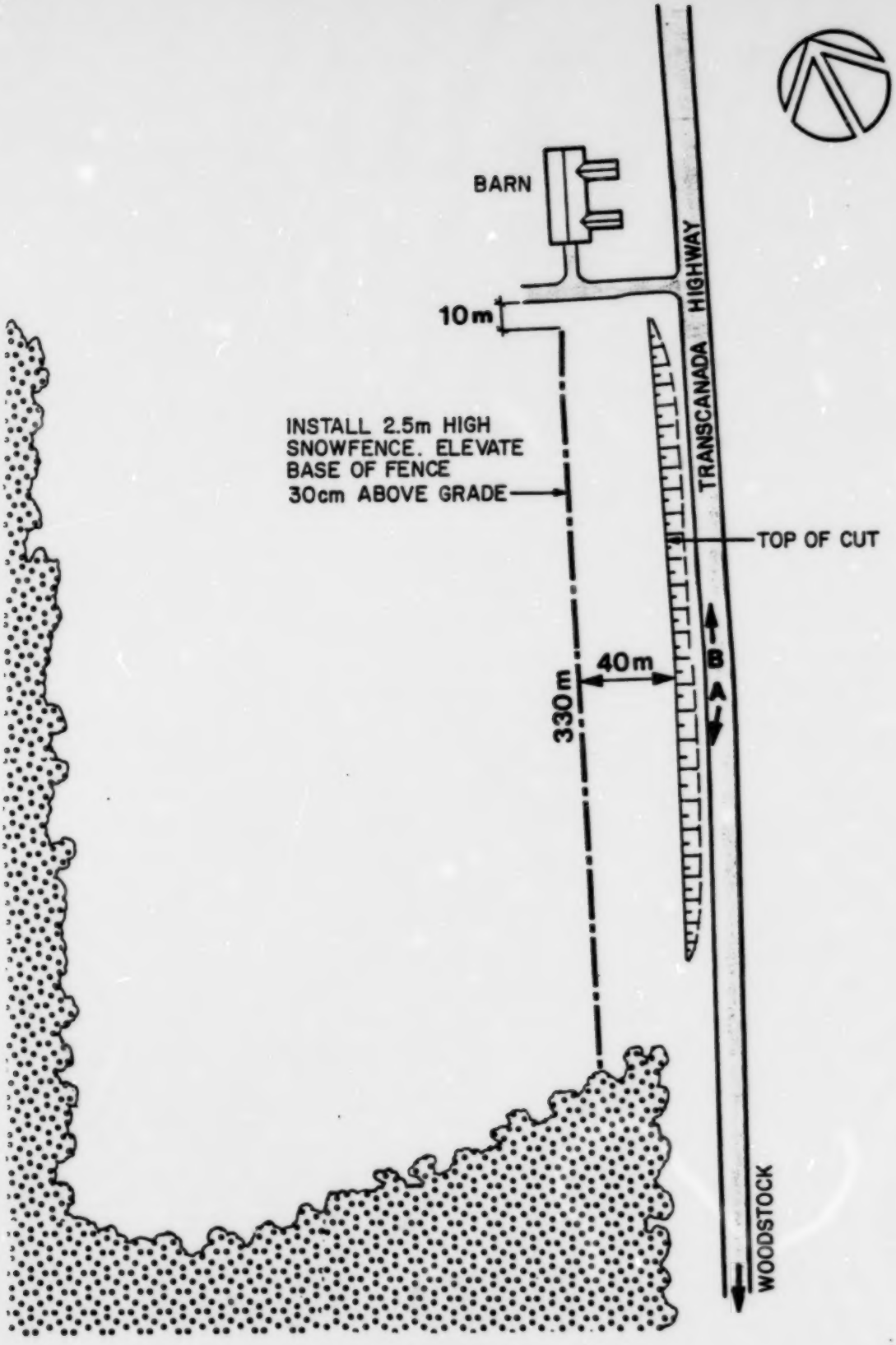


FIGURE D–30–2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 9–2 TRANSCANADA HIGHWAY, WATERVILLE

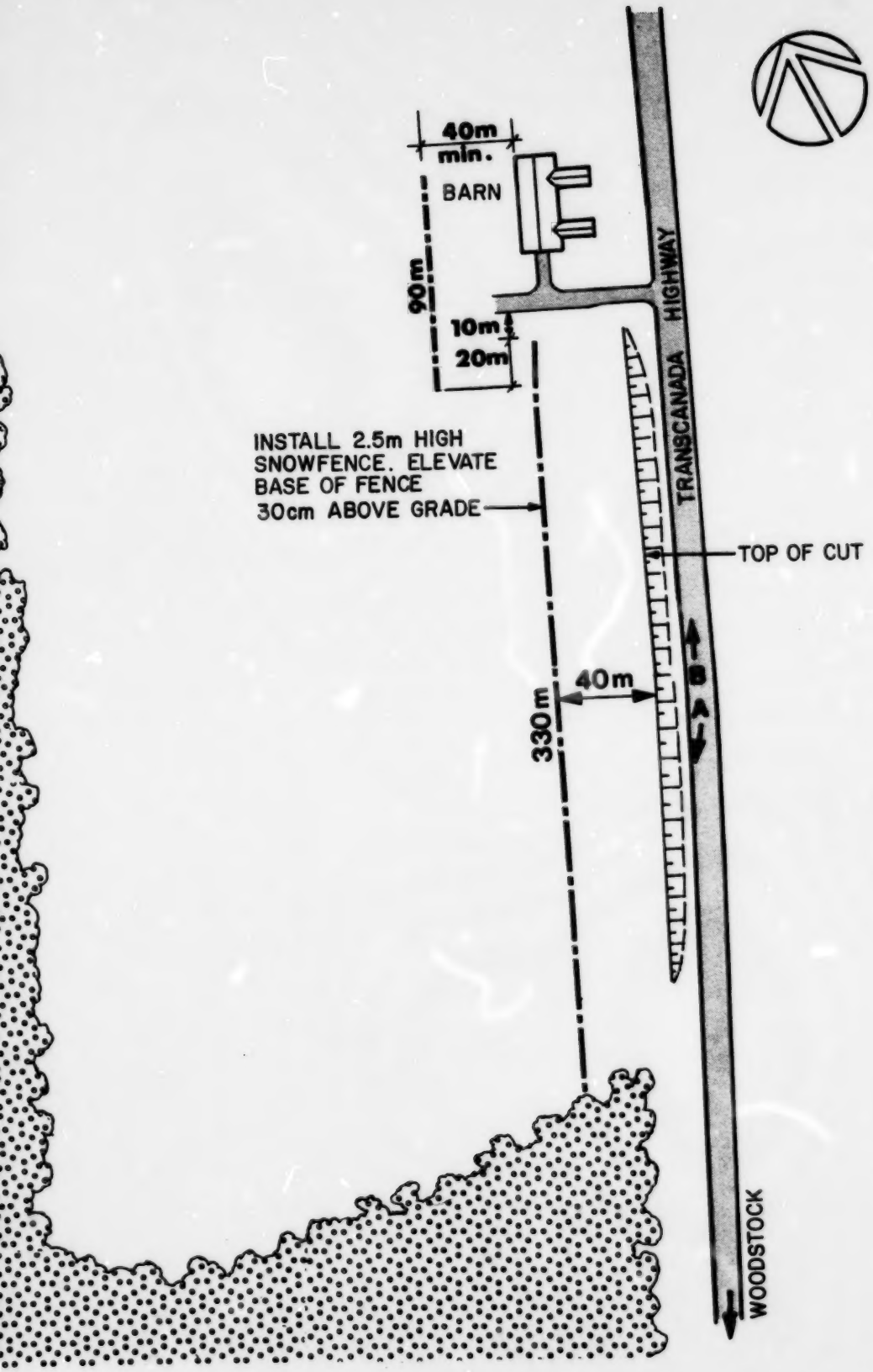


FIGURE D–30–3

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 9–2 TRANSCANADA HIGHWAY, WATERVILLE

APPENDIX D-31

SITE SUMMARY

SITE NUMBER: 9-3

SITE NAME: Route 560

SITE LOCATION: South of McQuarry Road, Woodstock

PROVINCE; New Brunswick

PRIMARY CONTACT: Clive Wood
New Brunswick, Department of Transport
Fredericton

DESCRIPTION OF PROBLEM:

The highway at this site has recently been reconstructed to straighten a bend in the road. However, the road passes through a small cut which causes snow to accumulate on the road. To complicate this situation a driveway intersects the highway midway along the curve. The snow cleared from the end of the driveway is piled on either side and increases the height of the snowbanks adjacent to the road. Indications from the road crew is that the prevailing wind is from the north direction, however, during the course of the study the prevailing winds have proven to be more northwesterly in direction.

PROBLEM IDENTIFICATION SITE VISIT:

Since the site was added to the study after the 1986-87 winter, the above problem has been confirmed by the road crews working in the area as well as the adjacent property owner.

RECOMMENDED SOLUTION:

Due to the high volume of snowdrifting in this area, it would be necessary to install a 2.5m high fence to adequately collect the snow. However, there is only 40m of right-of-way on the north side of the roadway (see Figure D-31-2). To properly locate a 2.5m fence it would have to be located on private property. Instead, it was decided to regrade the upwind cut and create a large ditch (see Section B-B, Figure D-31-3) and place a snowfence at the top of the backslope. This detail would effectively collect as much snow as a 2.5m high fence. In addition, the sideslopes of the driveway should be regraded to 7:1 or less (Section C-C, Figure D-31-3).

SOLUTION ASSESSMENT SITE VISITS:

1) On February 23, 1988, a site visit was conducted to assess the effectiveness of the installed solution. Although, the snow cover did not permit a full inspection of the

regrading, it appeared that the solutions detailed in Figures D-31-2 and D-31-3 had been incorporated into the site. As indicated in Figure D-31-1, the snow accumulations at the road measured up to 1.0m deep and downwind of the snowfence up to 1.2m deep. Close inspection of the snowdrifting patterns indicated that the prevailing winds were northwesterly. As a result, the west section of fence was causing snowdrifts on the adjacent driveway and the east section of fence was buried by the drifts caused by the terrain. It was decided that before the next winter, the snowfence layout should be changed. Figure D-31-4 shows the revised layout which eliminated the east fence and extended the west fence.

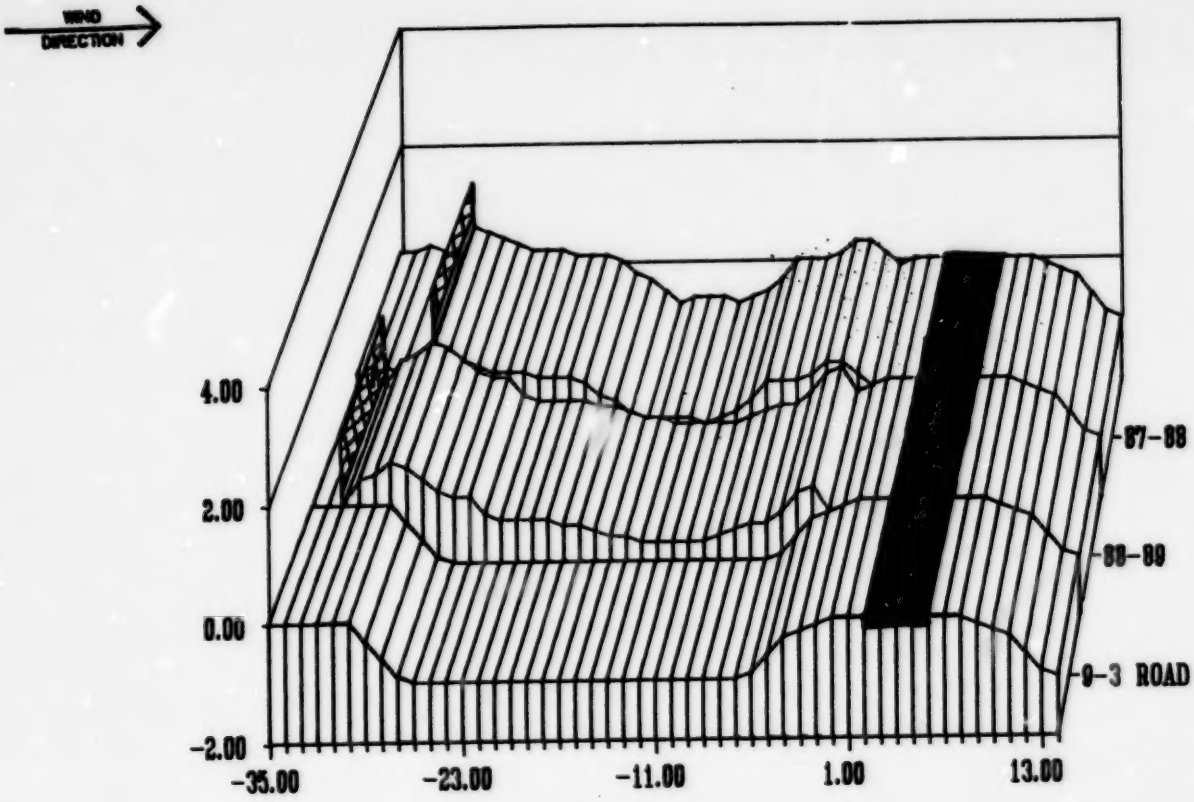
2) On March 1, 1989, a second solution assessment site visit was conducted. Observations of the installed solution indicated that the revised snowfence layout shown in Figure D-31-4 had been installed. The only deficiency was that the 1.2m high fence was installed with a 90 degree corner adjacent to the driveway instead of being rounded as the drawing had shown. This corner caused a long drift to extend from the corner towards the driveway. In the future, this detail should be changed to either be rounded or have 2-45 degree turns with the diagonal length equal to 15m. The measured accumulations were iess than 0.7m at the road and up to 1.2m adjacent to the fence (see Figure D-31-1).

RECOMMENDED SOLUTION:

The continued use of the solutions detailed in Figure D-31-4 are recommended. However, road crews servicing this highway should continue to monitor the effectiveness until a more typical winter occurs. At that time, the effectiveness of the solutions should be reassessed and the appropriate action taken.

CONCLUSIONS:

From meteorological data collected at Fredericton Airport, weather conditions during the 1987-88 winter were nearly average, however, 1988-89 was considerably below average. Despite these less than average conditions the revised design should adequately protect the site.



TYPICAL CROSS SECTION AT STUDY SITE

FIGURE D-31-1

TYPICAL SNOW ACCUMULATIONS

SITE 9-3 HIGHWAY 560, SOUTH OF McQUARRY ROAD

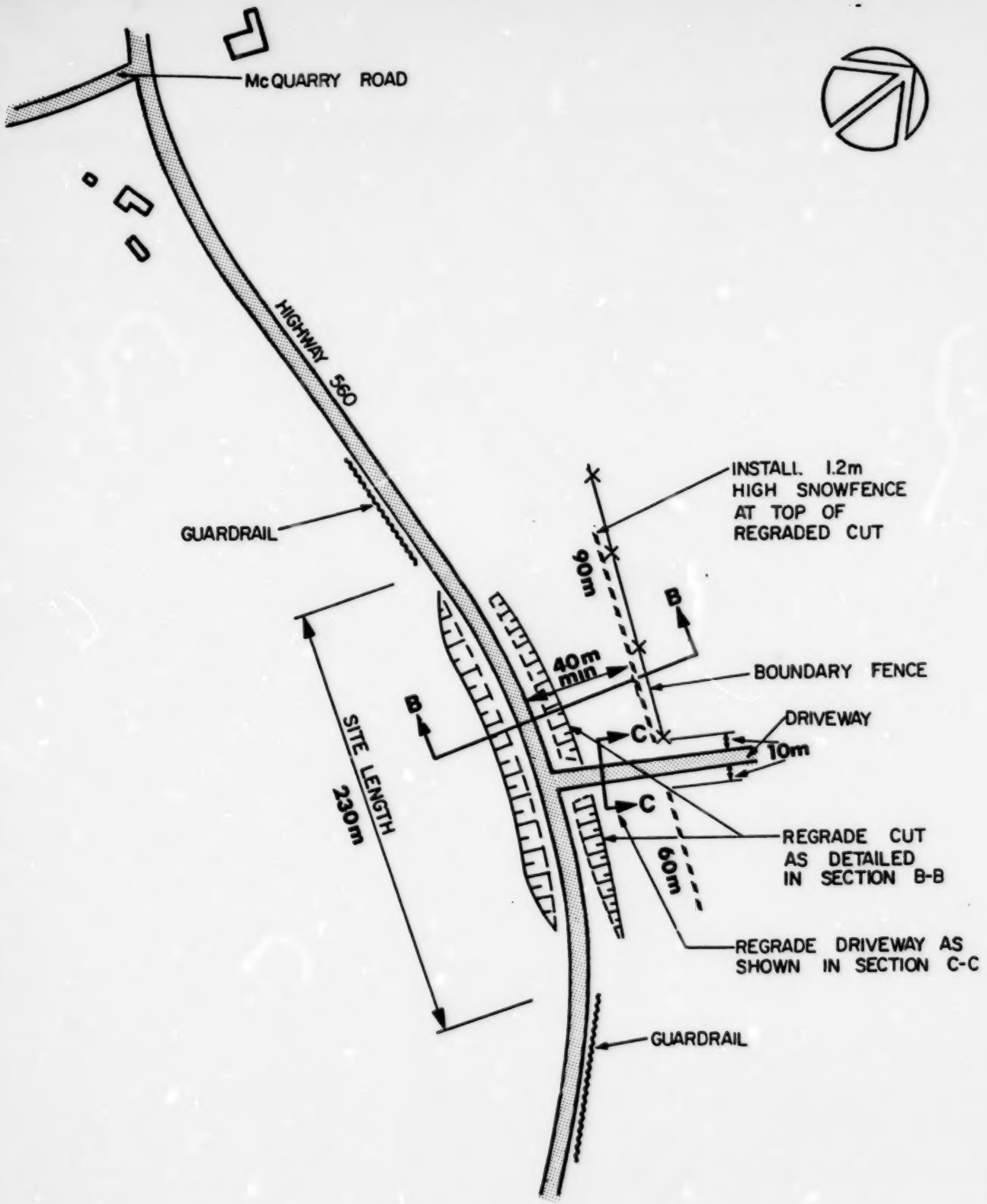
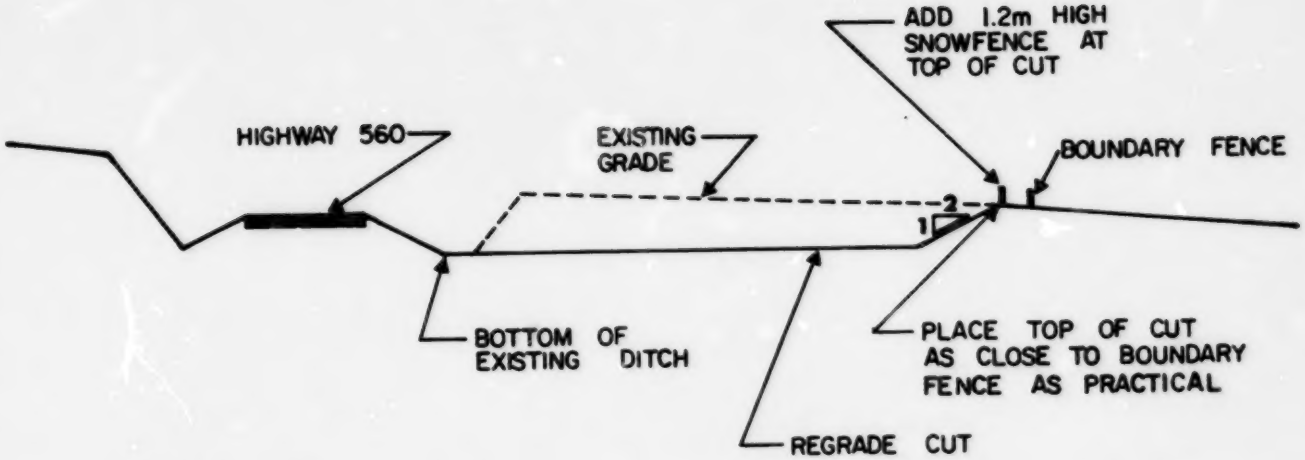


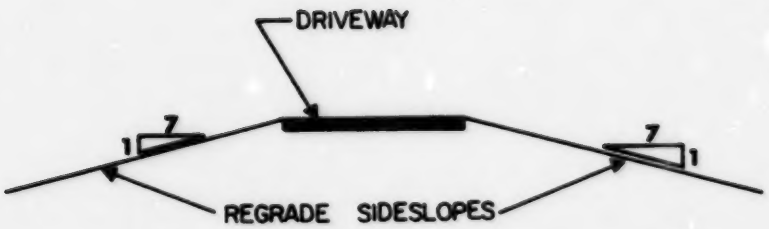
FIGURE D-31-2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 9-3 HIGHWAY 560, SOUTH OF McQUARRY ROAD



SECTION B-B



SECTION C-C

FIGURE D-31-3

DETAILS OF RECOMMENDED SOLUTIONS

SITE 9-3 HIGHWAY 560, SOUTH OF McQUARRY ROAD

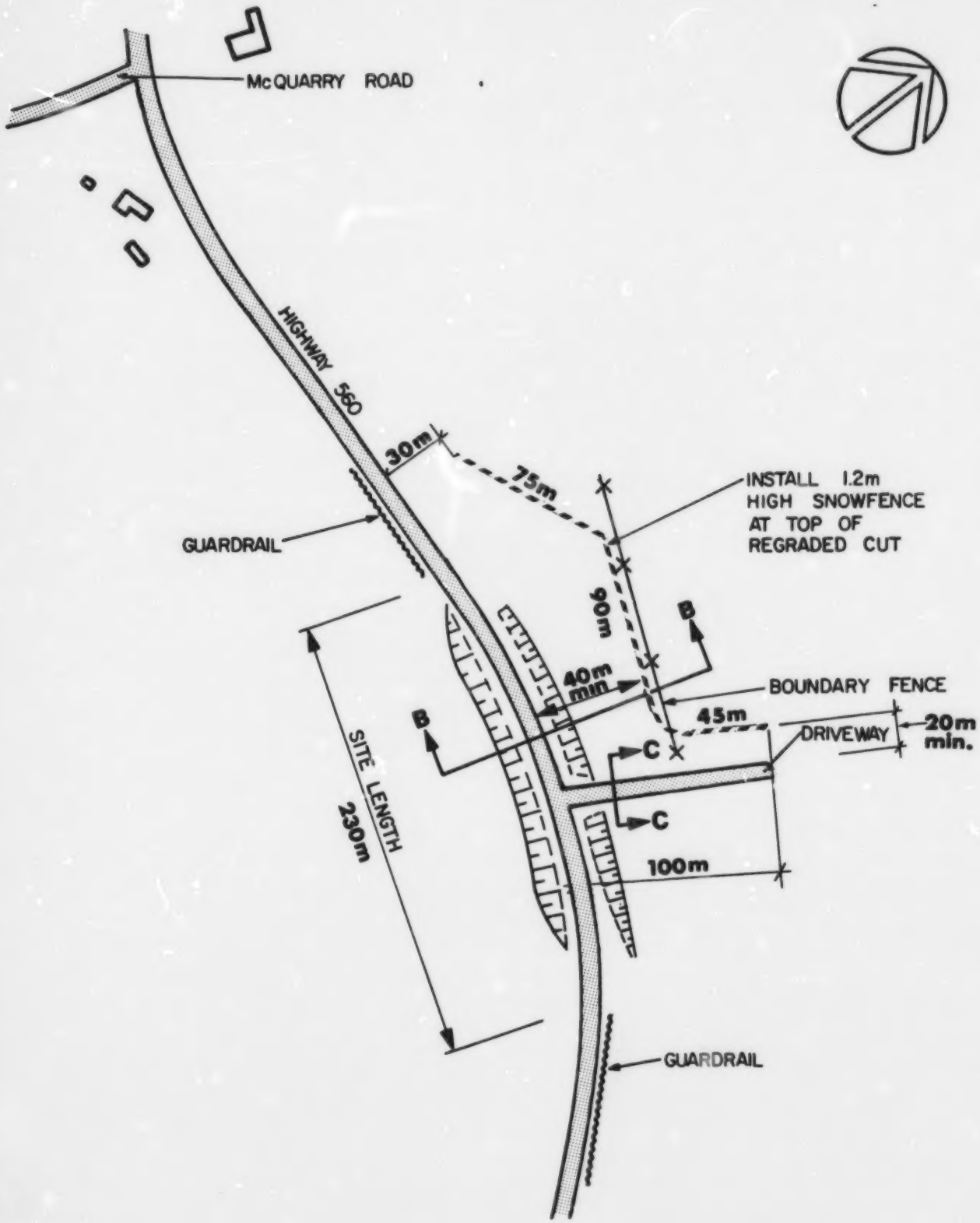


FIGURE D-31-4

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 9-3 HIGHWAY 560, SOUTH OF McQUARRY ROAD

APPENDIX D-32

SITE SUMMARY

SITE NUMBER: 9-4

SITE NAME: Trans Canada Highway

SITE LOCATION: Tantramar Marsh, Aulac

PROVINCE; New Brunswick

PRIMARY CONTACT: Clive Wood
New Brunswick, Department of Transport
Fredericton

DESCRIPTION OF PROBLEM:

The TransCanada Highway in this area passes through a marsh and is oriented in a northwest by southwest direction. The road is located to the northeast of a railroad track, which is raised about 3m above the road. In one situation the road is located within 30m of the tracks while the at another location the road is approximately 100m away. The indication from the field crew was that the prevailing winds occur from the southwest and the storm winds occur from the northeast.

This scenario would suggest white out conditions in the wake of the raised track and a build up a snow on the southwest side of the road located further from the track. This information conflicted with recent photos taken at the site, which show 2-3m snowbanks on the opposite side of the road (northeast side).

PROBLEM IDENTIFICATION SITE VISIT:

As this site was not added to the study until the summer of 1987 and the reason for the problem was not obvious it was decided that the 1987-88 winter would be used for problem identification, unlike the balance of the sites where the solutions had been installed prior to this winter. It was decided that a number of reference conditions would be created to assist in understanding snowdrifting conditions at the site.

RECOMMENDED SOLUTION:

As shown in Figure D-32-1 a 300m long 2.5m high section of snowfence was recommended on the northeast side of the highway as a test section in the vicinity of the abandoned gas station.

SOLUTION ASSESSMENT SITE VISITS:

1) Due to less than then typical snowdrifting conditions at this site a solution assessment site visit was not conducted. It was reported to us through Clive Wood that the fence was installed on the northeast side of the road, but in a different area of the site. This report indicates that the snowfence worked well at improving the adjacent road conditions, particularly when snowdrifting occurred. Evidently, a severe wind storm occurred on April 7, 1989 which blew from the southwest at over 100km/h, which ripped the fence material from the posts.

CONCLUSIONS:

The information gathered at this site and Moncton Airport indicated that the prevailing winds affecting snowdrifting at this site occur from a northeasterly direction.

One of the problems which caused snow to accumulate at the highway is the road is approximately at the same level as the surrounding terrain. If elevated the wind would blow the snow off the paved surface as well as creating a reservoir for plowed snow.

RECOMMENDATIONS:

It is recommended that when the highway is reconstructed that it be elevated approximately 1.5m above the surrounding terrain and as far as practical from the railway tracks to minimize the effects of wind turbulence generated by the lesser frequent southwest winds. In the interim 2.5m high fences could be used to collect drifting snow by locating them a minimum of 40m away from the road on the northeast side.

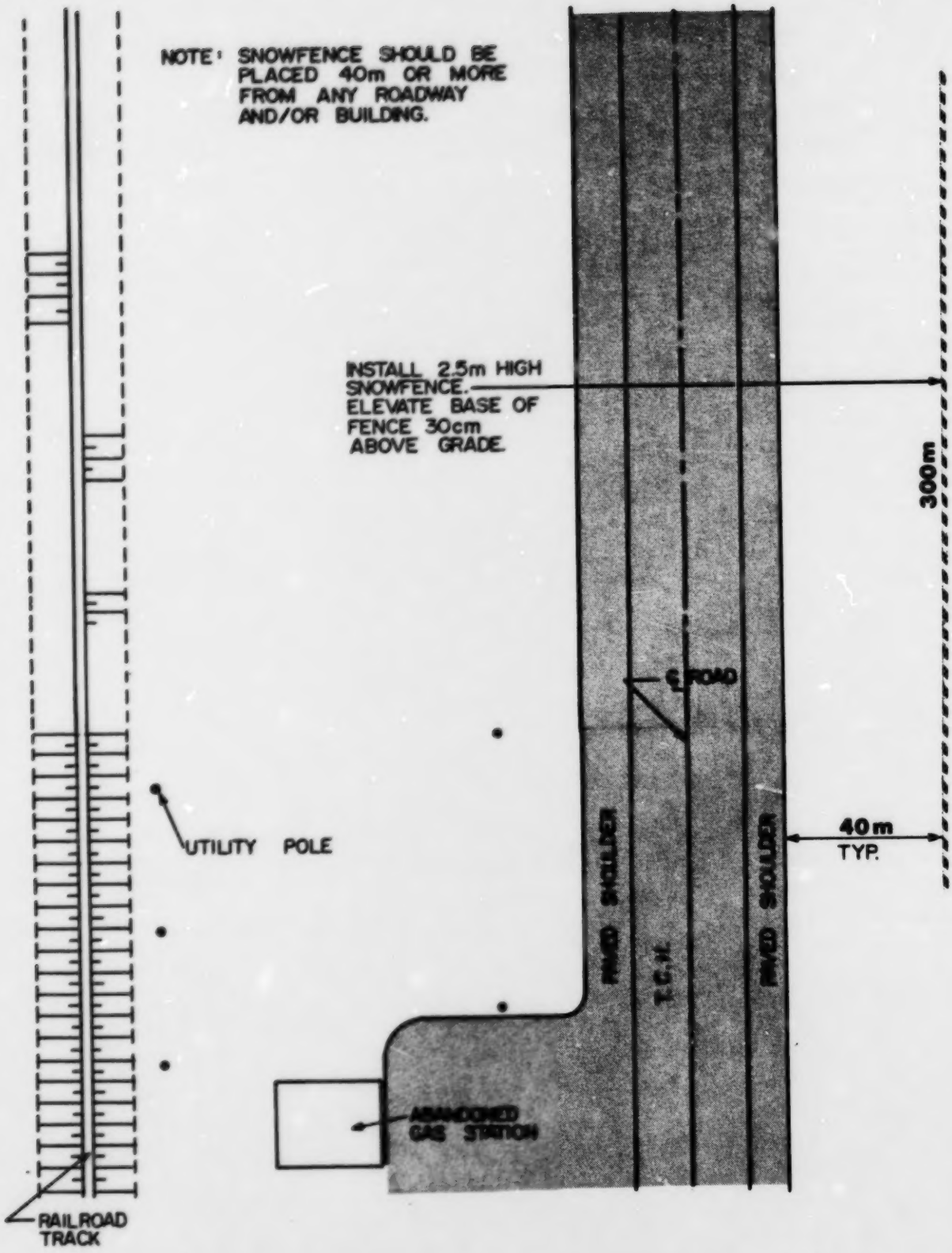


FIGURE D-32-1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING
SITE 9-4 TRANSCANADA HIGHWAY, TANTRAMAR MARSH

APPENDIX D-33

SITE SUMMARY

SITE NUMBER: 9-5

SITE NAME: Route 15

SITE LOCATION: Emery Leger Road, Cape Pele

PROVINCE; New Brunswick

PRIMARY CONTACT: Clive Wood
New Brunswick, Department of Transport
Fredericton

DESCRIPTION OF PROBLEM:

The highway at this site is oriented in an east-west direction and is lined on both sides with houses. Beyond the houses to the north is open terrain and Northhumberland Strait. During the winter snow is blown off the frozen water over the open terrain and accumulates on the adjacent highway downwind of the houses. Photographs taken at the site by members of New Brunswick Department of Transport show accumulations greater than 5m deep adjacent to the road during the 1986-87 winter.

RECOMMENDED SOLUTION:

With the use of data collected at the site and Moncton Airport the snowfence arrangement shown in figure D-33-1 was developed and installed prior to the 1987-88 and 1988-89 winters.

PROBLEM IDENTIFICATION SITE VISIT:

Since this site was added after the 1986-87 winter the problem was not observed first hand. Assessment of the problem was done through photographs taken by the New Brunswick Department of Transport.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 24, 1988 a solution assessment site visit was conducted. The two rows of 2.5m high snowfence that were installed collected snow measuring up to 1.8m in depth. In addition snow accumulations of up to 1.5m deep were noted adjacent to the highway. Although, this improvement is not fully the result of the solution. From Appendix F the peak ground snow cover recorded at nearby Moncton Airport measured 69 cm during the 1987-88 winter, compared to 92cm the winter before. This reduced snow cover is likely the major factor in the reduced accumulations.

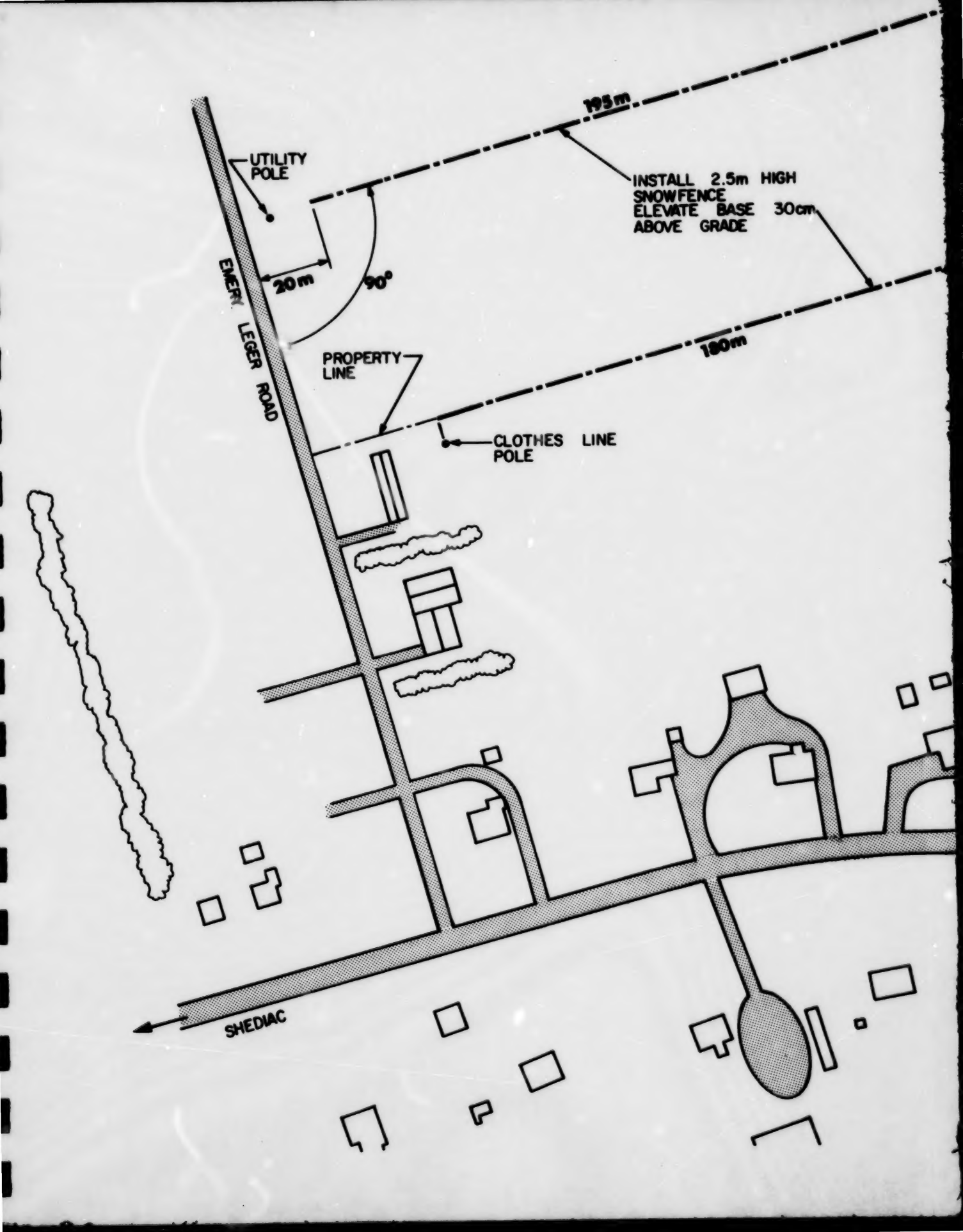
2) During the 1988-89 winter snow drifting conditions were much less than typical and as a result a site visit was not conducted. Even the reports returned by the road crew indicated very little snowdrifting occurred.

CONCLUSIONS:

Due to the less than typical snowdrifting conditions that occurred during the course of the study it is difficult to conclude how effective the fences were. It does appear that the fences are located properly and that the snow accumulations adjacent to them are not adversely affecting their surroundings.

RECOMMENDATIONS:

It is recommended that the snowfence arrangement shown if Figure D-33-1 be used in the future at least until a more typical winter occurs. At that time its continued use can be decided. It may be possible to eliminate one of the rows of snowfence since their are some indications from current observations that 1 row of 2.5m high snowfence is adequate. Future considerations could be given to replacing these temporary snowfences with coniferous trees. If this is decided it is recommended that the manual developed as a companion to this report be consulted to obtain the appropriate details.


195m
UTILITY POLE
INSTALL 2.5m HIGH SNOWFENCE ELEVATE BASE 30cm ABOVE GRADE
20m
90°
EMERY LEGER ROAD
180m
PROPERTY LINE
CLOTHES LINE POLE
SHEDIAC

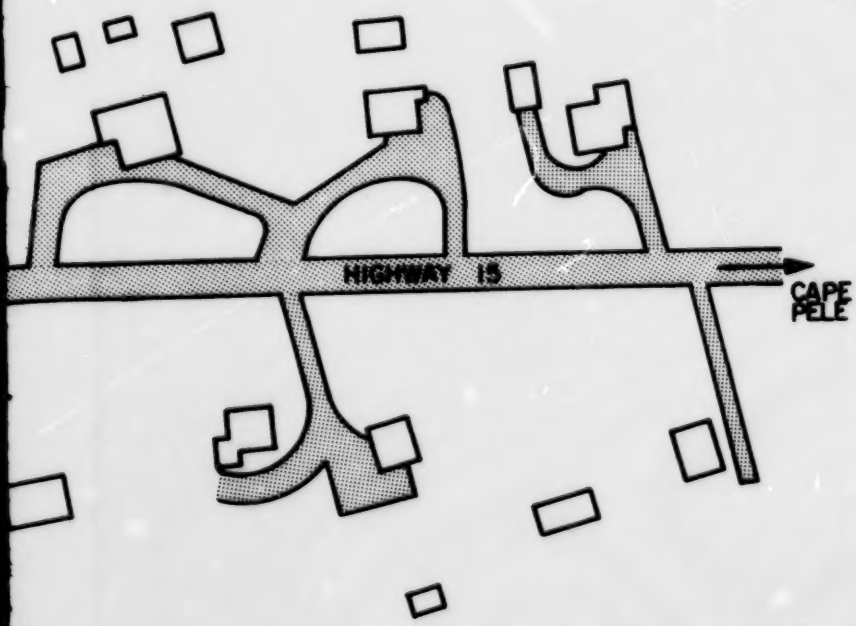


FIGURE D–33–1

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 9–5 HIGHWAY 15 AT EMERY LEGER ROAD

APPENDIX D-34

SITE SUMMARY

SITE NUMBER: 9-6

SITE NAME: Route 11

SITE LOCATION: North of Sunset Drive, Bathurst

PROVINCE; New Brunswick

PRIMARY CONTACT: Clive Wood
New Brunswick, Department of Transport
Fredericton

DESCRIPTION OF PROBLEM:

The TransCanada Highway at this location is oriented in a northwest by southeast direction. The shoulder of the road has been widened to create a truck stop. Unfortunately all of the snow which is plowed to the shoulder cannot be stored in the adjacent ditch. The resultant snow banks cause calm air regions for drifted snow to accumulate in. In order to minimize the snow that drifts towards the road it was agreed by the New Brunswick Department of Transport that snowfencing was the appropriate solution.

RECOMMENDED SOLUTION:

In Appendix F the meteorological data recorded at Charlo, N.B. indicates that the prevailing winds are from the west and the 2.5m high snowfence layout shown in Figure D-34-2 locates the fences normal to these winds.

PROBLEM IDENTIFICATION SITE VISIT:

Since this site was added after the 1986-87 winter the problem conditions were not observed first hand. However a reference site located to the south of the study site was used to gauge the effectiveness of the solutions (see Figure D-34-1).

SOLUTION ASSESSMENT SITE VISITS:

1) On February 25, 1988 a site visit was conducted to assess the effectiveness of the installed remedial solutions. The snowfence arrangement shown in Figure D-34-2 had been installed except only 120m of the 150m long fence was erected due to wet soil conditions during installation. As can be seen in Figure D-34-1 more snow has accumulated adjacent to the road at the reference site than at that study site. This is as a result of the snow collection capabilities of the installed snowfence protecting the highway at the study site.

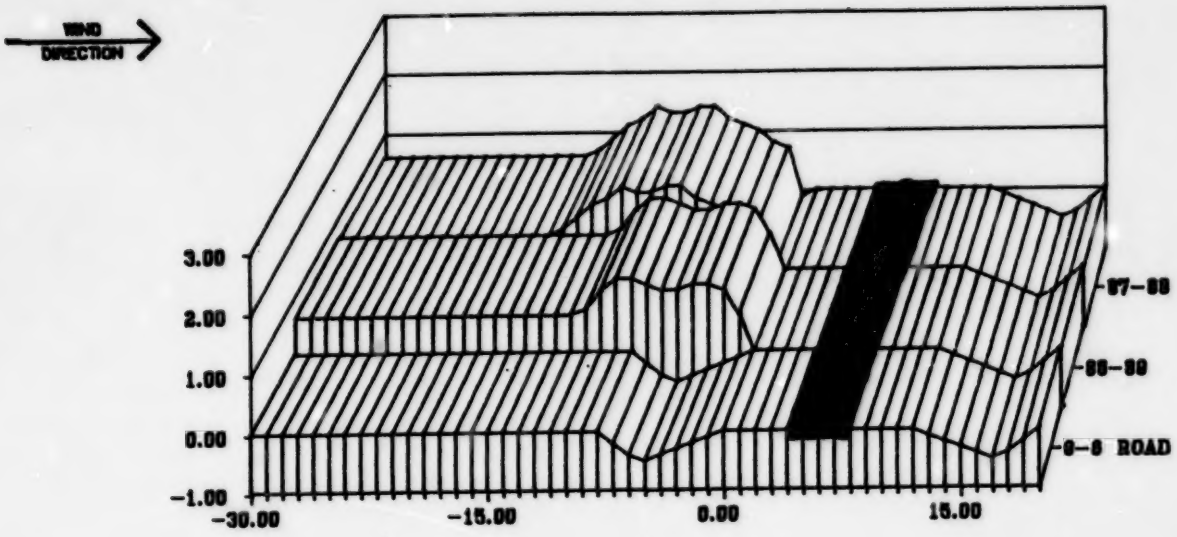
2) On February 28, 1989 a second solution assessment site visit was conducted. It was noted that the recommended snowfence layout shown in Figure D-34-2 had been installed and the 45m fence was extended to approximately 135m. Similar to the previous year the reference site had larger accumulations adjacent to the west side of the road than at the study site (See Figure D-34-1).

CONCLUSIONS:

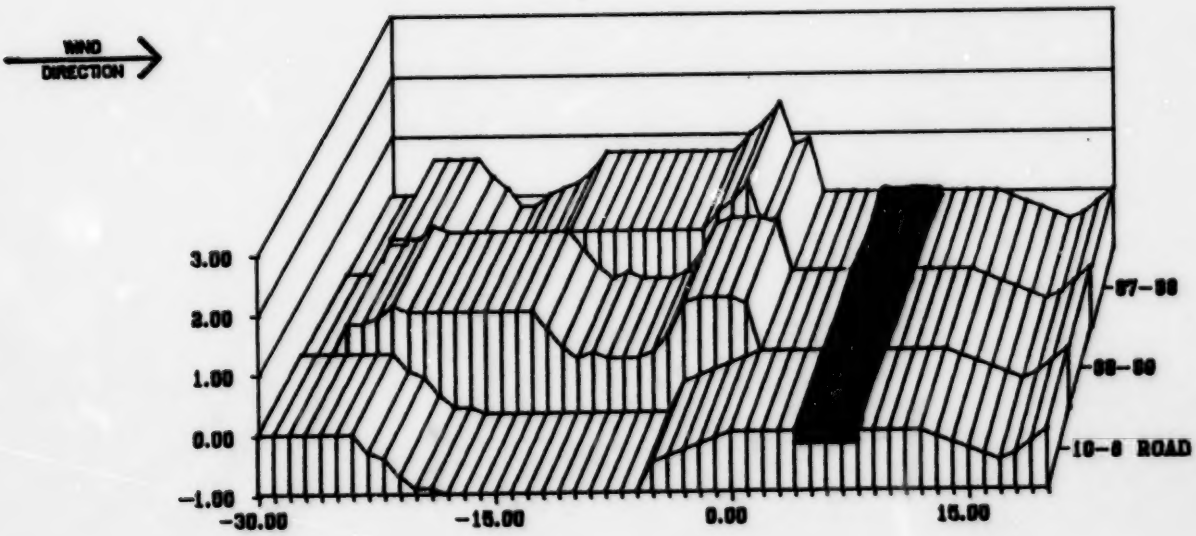
From Appendix F the snow conditions at nearby Charlo Airport were typical for the 1987-88 and 1988-89 winters particularly the peak ground snow cover and blowing snow conditions. As a result the solutions have received a good test of typical conditions. The fact that the snowfences are arranged in an effective double row configuration and that they only were half full of snow at the end of the winter the number of effective rows could be reduced to one in the future. This could be done by removing the 105m and 45m lengths and reducing the 210m lengths to 150m measuring along the 30 degree angle beginning at the 30m setback.

RECOMMENDATIONS:

It is recommended that the New Brunswick Department of Transport continue to use the snowfencing arrangement shown in Figure D-34-2 with the alterations discussed in the above conclusions.



TYPICAL CROSS SECTION AT STUDY SITE



TYPICAL CROSS SECTION AT REFERENCE SITE

FIGURE D-34-1

TYPICAL SNOW ACCUMULATIONS

SITE 9-6 HIGHWAY 11, NORTH OF SUNSET DR., BATHURST

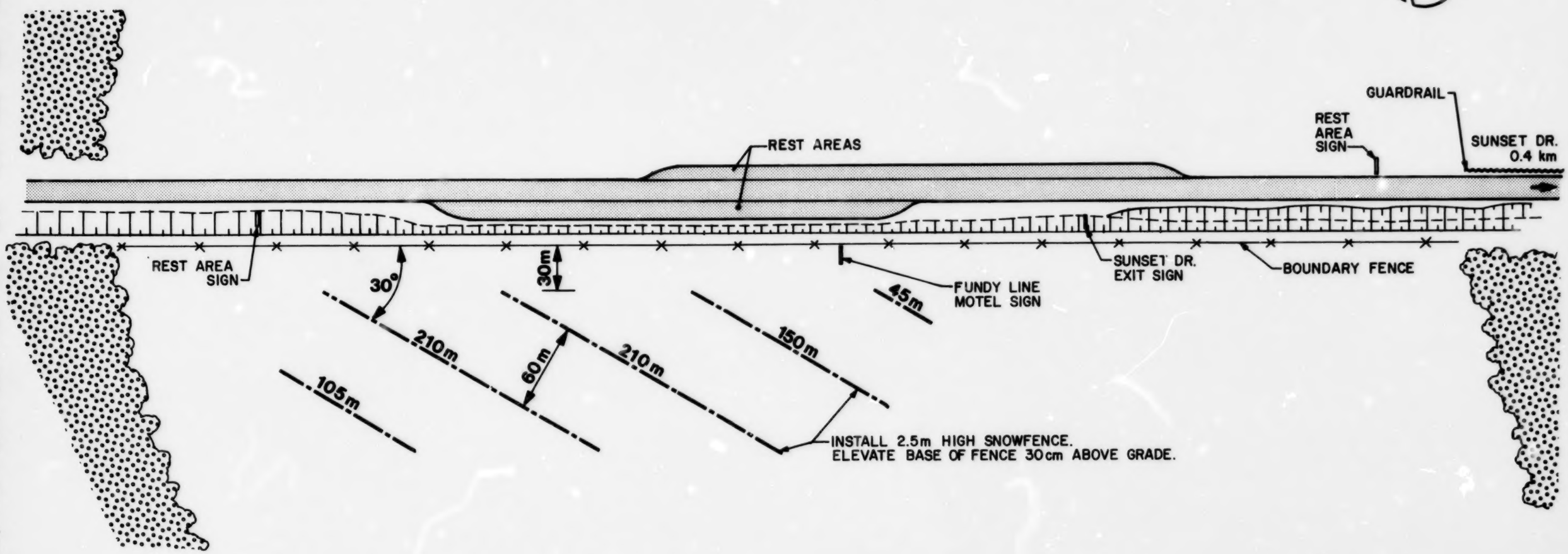


FIGURE D–34–2

RECOMMENDATIONS TO REDUCE SNOWDRIFTING

SITE 9–6 HIGHWAY 11, NORTH OF SUNSET DR., BATHURST

RWDI

APPENDIX D-35

SITE SUMMARY

SITE NUMBER: 9-7

SITE NAME: Route 11

SITE LOCATION: Janeville

PROVINCE; New Brunswick

PRIMARY CONTACT: Clive Wood
New Brunswick, Department of Transport
Fredericton

DESCRIPTION OF PROBLEM:

The highway in the vicinity of this site is oriented in a southwest by northeast direction and is generally lined with houses on both sides of the road. Upwind of the road (northward) is open terrain and the Bay of Chaleur. The wind blows snow off the ice surface and deposits it in the calm air regions along the highway adjacent to the buildings. From photographs taken at this site by the New Brunswick Department of Transport in February 1982, these accumulations are estimated to be in excess of 6m high.

PROBLEM IDENTIFICATION SITE VISIT:

Since this site was not included in the study until the 1987-88 winter, the problem conditions were not experienced first hand. The problem conditions were identified through the use of photographs mentioned above taken during the 1981-82 winter. In order to gauge the effectiveness of the installed solution, a reference site was established 3.7 km west of the study site in a similar problem condition. Typical snow accumulations measured at both sites are included in Figure D-35-1.

RECOMMENDED SOLUTION:

A double row of 2.5m high fences was designed as the solution for this site as shown in Figure D-35-2 with a long range plan of planting coniferous trees to replace the temporary snowfences.

SOLUTION ASSESSMENT SITE VISITS:

1) On February 25, 1988, a site visit was conducted to assess the effectiveness of the installed snowfences. Our observations indicated that the snowfence layout shown in Figure D-35-2 had been erected without provision for winter access along the adjacent laneway. As shown in Figure D-35-1, depths of up to 2.0m in depth were recorded in the ditch upwind of the road. Whereas similar measurements at the reference site

were up to 3m deep. It was also noted that the snowfence caused some drifting on the laneway located to the east of the Robert Hornibrook Garage.

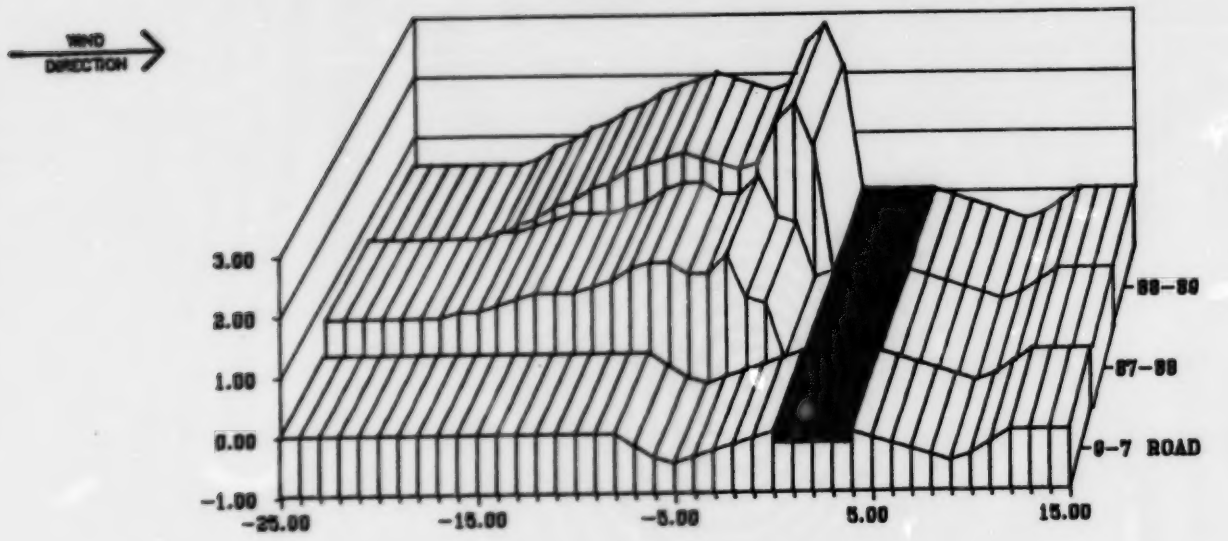
2) On February 28, 1989, a second solution assessment site visit was conducted. It was observed that the snowfences had been installed as shown in Figure D-35-2 and an access was provided for the lane located to the west of the Robert Hornibrook Garage. The solution appeared to be less effective this winter when compared to the reference site. As shown in Figure D-35-1, snow depths of up to 3.0m deep were observed upwind of the road at the study site compared to less than 1.5m at the reference site. It was apparent from looking at the drift patterns around the snowfence that the prevailing winds blew more from the west this year compared to more northerly winds the previous year. As a result, the fences were not long enough to protect the study site and other surrounding buildings at the reference site protected it. Similar to the previous winter, the snowfences caused drifting on the laneway located east of the Robert Hornibrock Garage.

CONCLUSIONS:

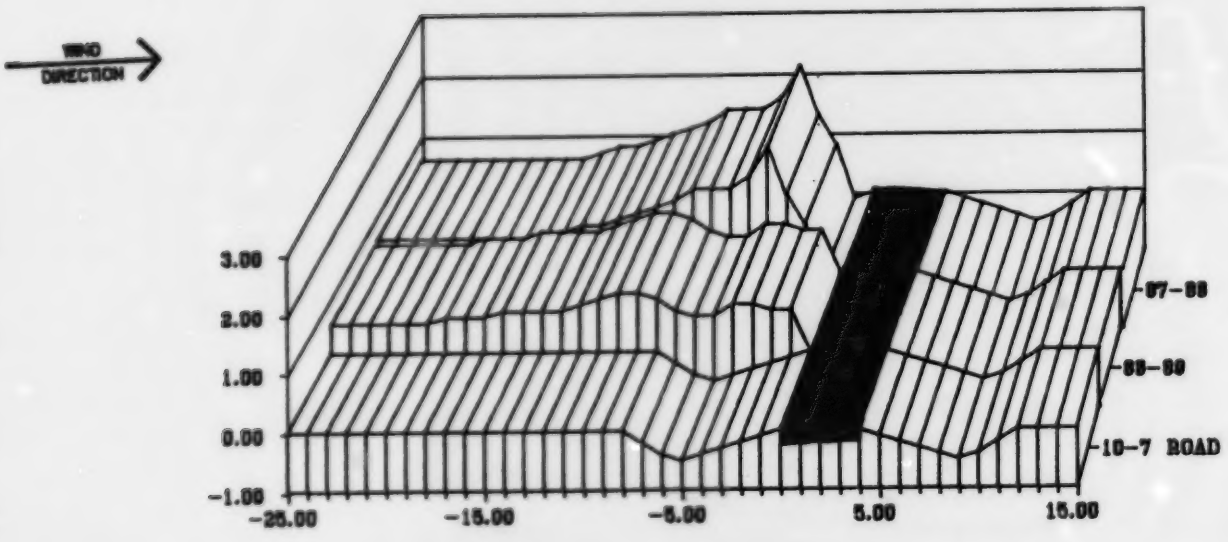
Even though the meteorological data contained in Appendix F for Charlo Airport indicates that the 1987-88 and 1988-89 winter were typical, the drifting conditions at this site appear less than typical. As a result, it is difficult to conclude if the snowfence were fully effective.

RECOMMENDATIONS:

It is recommended that the snowfencing arrangement shown in Figure D-35-2 be installed in the future until it experiences a typical winter. At that time, its continued use can be decided. If a landscaping solution is ultimately decided upon, then the companion manual to the report should be consulted for guidelines of the planting types, locations, etc.



TYPICAL CROSS SECTION AT STUDY SITE



TYPICAL CROSS SECTION AT REFERENCE SITE

FIGURE D-35-1
TYPICAL SNOW ACCUMULATIONS
SITE 9-7 HIGHWAY 15, JANEVILLE

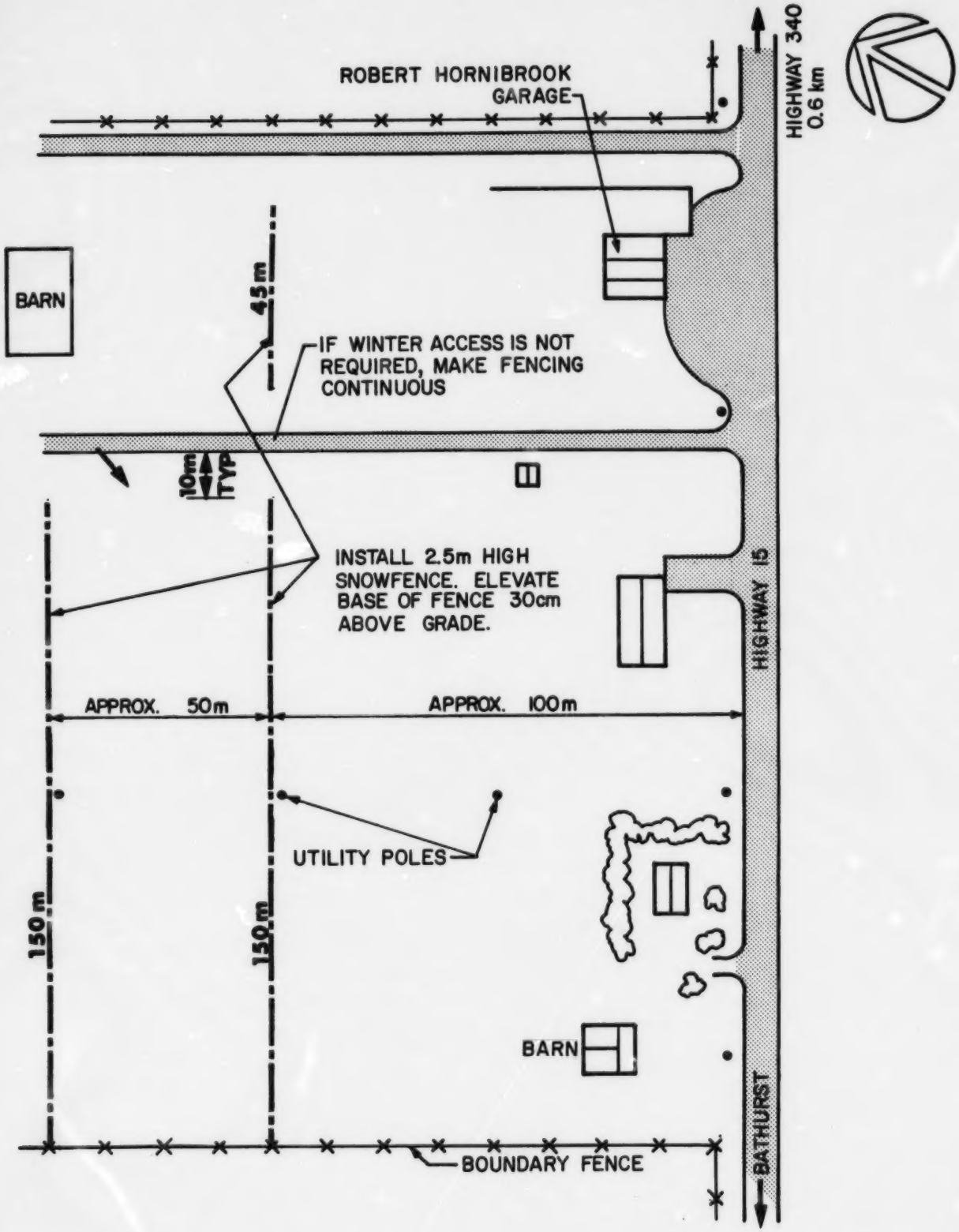


FIGURE D-35-2

RECOMMENDATION TO REDUCE SNOWDRIFTING

SITE 9-7 HIGHWAY 15, JANEVILLE

APPENDIX E

SNOWDRIFTING STUDY OF CANADIAN HIGHWAYS

RECORD OF SNOWDRIFTING EVENTS
WINTER OF 1987 - 88

SITE 1-14
HIGHWAY 550, SAULT STE. MARIE

STUDY CONDUCTED BY:

ROWAN WILLIAMS DAVIES & IRWIN INC.
650 WOODLAWN ROAD WEST
GUELPH ONTARIO
N1K 1B8

CONTRACTED BY:

TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA
MONTREAL QUEBEC

SNOWDRIFTING STUDY OF CANADIAN HIGHWAYS

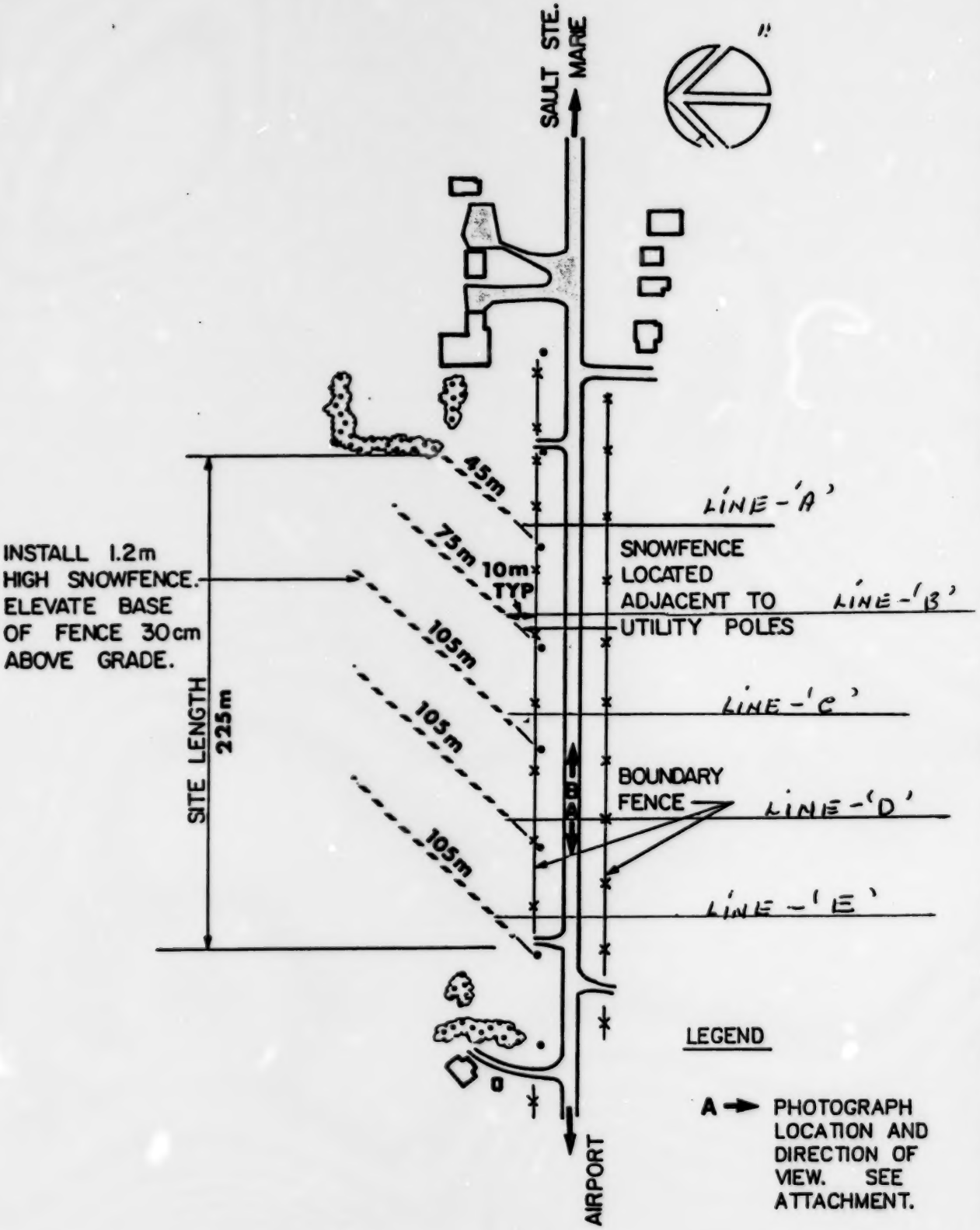
RECORD OF SNOWDRIFTING EVENTS

SITE 1-14

HIGHWAY 550, SAULT STE. MARIE

EVENT NO.	(1)	(2)	(3)	(4)	(5)	(6)
A) DATE	DEC-31	JAN. 4 88	JAN. 11 88	JAN-20/88	FEB-8/88	FEB. 20/88
B) TIME OF OBSERVATION	2:10 PM	11:10 AM	3:00 PM	2:30 PM	10:15 AM	10:30 AM
C) LENGTH OF EVENT (hr)	5	30	3	8	3	4
D) TEMPERATURE (C)	0	-10	-8	-2	-12	-18
E) AMOUNT OF SNOWFALL DURING EVENT (cm)	5 cm	29 cm	5 cm	17 cm	2.5 cm	2.0 cm.
F) GROUND SNOW COVER IN NEARBY OPEN FIELD (cm)	35 cm	42 cm	40 cm.	25 cm	27 cm	35 c.m.
G) WIND DIRECTION	S.W.	N.W.	N.W.	N.E.	N.W.	N.W.
H) WIND SPEED (circle one) - slow - medium - fast	S (M) F	S M (F)	S M (F)	S (M) F	S (M) F	S M (F)
I) WAS THE ROAD CLOSED BECAUSE OF THIS SNOWDRIFTING EVENT? (circle one)	Y (N)	Y (N)	Y (N)	Y (N)	Y (N)	Y (N)
J) WAS ANY EXTRA EQUIPMENT USED TO CLEAR THE ROAD AT THIS SITE THAN IS NORMALLY USED? (yes or no)	Y (N)	Y (N)	Y (N)	Y (N)	Y (N)	Y (N)
K) IS THE SNOWDRIFT AT THE SNOWFENCE EQUAL TO OR HIGHER THAN THE TOP OF THE SNOWFENCE? (yes or no)	Y (N)	Y (N)	Y (N)	Y (N)	Y (N)	Y (N)
L) ARE SNOW CONDITIONS AT THIS SITE BETTER, WORSE OR THE SAME AS PREVIOUS WINTERS? (circle one)	B W (S)	B W (S)	B W (S)	B W (S)	B W (S)	(B) W S
M) COMMENTS:						

EVENT NO.	(7)	(8)	(9)	(10)	(11)	12
A) DATE	FEB. 23/88	FEB. 29/88	MAR. 3/88	MAR. 12/88	MAR. 18/88	
B) TIME OF OBSERVATION	9:30 A.M.	10:40 AM	10:20 AM	11:00 AM	10:10 A.M.	
C) LENGTH OF EVENT (hr)	3	3	3	13	10	
D) TEMPERATURE (C)	+3 ↓	-1 ↓	-3 ↓	-5	-8	
E) AMOUNT OF SNOWFALL DURING EVENT (cm)	2.5 cm	2.0 cm	3.0 cm	20.0 cm	5.0 cm	
F) GROUND SNOW COVER IN NEARBY OPEN FIELD (cm)	35 cm.	32 cm	32 cm	15 cm	15 cm	
G) WIND DIRECTION	N.W.	N.W.	N.W.	N.E.	N.W.	
H) WIND SPEED (circle one) - slow - medium - fast	S (M) F	S (M) F	S (M) F	S (M) F	S (M) F	S M F
I) WAS THE ROAD CLOSED BECAUSE OF THIS SNOWDRIFTING EVENT? (circle one)	Y (N)	Y (N)	Y (N)	Y (N)	Y (N)	Y N
J) WAS ANY EXTRA EQUIPMENT USED TO CLEAR THE ROAD AT THIS SITE THAN IS NORMALLY USED? (yes or no)	Y (N)	Y (N)	Y (N)	Y (N)	Y (N)	Y N
K) IS THE SNOWDRIFT AT THE SNOWFENCE EQUAL TO OR HIGHTER THAN THE TOP OF THE SNOWFENCE? (yes or no)	Y (N)	(Y) N	(Y) N	(Y) N	(Y) N	Y N
L) ARE SNOW CONDITIONS AT THIS SITE BETTER, WORSE OR THE SAME AS PREVIOUS WINTERS? (circle one)	(B) W S	(B) W S	(B) W S	(B) W S	(B) W S	B W S
M). COMMENTS:						



RECOMMENDATIONS TO REDUCE SNOWDRIFTING
SITE 1-14 HIGHWAY 550, SAULT STE. MARIE

INSTRUCTIONS FOR COMPLETING LOG BOOK

TO

RECORD SNOWDRIFTING EVENTS

THE MOST IMPORTANT ASPECT OF RECORDING THIS INFORMATION IS TO DEFINE 'SNOWDRIFTING EVENT' . GENERALLY, THIS EVENT IS A DURATION OF TIME (FROM A FEW HOURS TO A COUPLE OF DAYS) THAT THE WIND IS BLOWING SNOW ACROSS THE ROAD. THE AMOUNT OF SNOW COULD RANGE FROM A THIN LAYER (1 OR 2 cm) TO A THICK LAYER (OVER 1 m). DEPENDING ON THE EFFECTIVENESS OF THE INSTALLED SOLUTION AT THE STUDY SITE IT MAY BE NECESSARY TO OBSERVE SNOW MOVEMENT ACROSS THE ROAD AT A NEARBY SITE. THE DESIGNATED OBSERVER WILL HAVE TO USE HIS/HER OWN DISCRETION. HOWEVER, IF THERE IS ANY DOUBT ASSUME THAT AN EVENT HAS OCCURRED AND RECORD OBSERVATIONS.

THE FOLLOWING ARE SPECIFIC COMMENTS FOR EACH SECTION OF THE LOG:

A) DATE

- RECORD THE DATE OF THE DAY ON WHICH THE EVENT ENDS

B) TIME OF OBSERVATION

- USE 12 HOUR CLOCK AND INCLUDE A.M. OR P.M.

C) LENGTH OF EVENT

- ESTIMATE LENGTH OF EVENT IN HOURS

D) TEMPATURE

- GIVE APPROXIMATE TEMPERATURE IN CELCIUS DEGREES

E) AMOUNT OF SNOWFALL DURING EVENT

- RECORD APPROXIMATE DEPTH OF SNOWFALL IN CENTIMETRES

F) GROUND SNOW COVER IN NEARBY OPEN FIELD

- ESTIMATE THE DEPTH OF SNOW COVERING THE ADJACENT FIELDS IN CENTIMETRES
- ENTER 0 cm IF MOST OF THE GRASS OR EARTH IS SHOWING IN THE FIELD

EVENT # 11 - LINE B
SITE # 1-14 - Bay # 1 S.C.

EVENT # 11 - LINE C
SITE # 1-14 - Bay # 1 S.C.

G) WIND DIRECTION

- USING THE PLAN OF THE STUDY SITE WHICH IS INCLUDED IN THIS LOG BOOK ESTIMATE THE DIRECTION THAT THE WIND CAME FROM DURING THE EVENT USING ONE OF THE FOLLOWING DIRECTIONS:

NORTH (N)
NORTHEAST (NE)
EAST (E)
SOUTHEAST (SE)
SOUTH (S)
SOUTHWEST (SW)
WEST (W)
NORTHWEST (NW)

H) WIND SPEED

- A PRECISE MEASUREMENT OF WIND SPEED WILL BE AVAILABLE FROM RECORDS KEPT AT A NEARBY WEATHER STATION SO, A VERY APPROXIMATE WIND SPEED WILL BE ADEQUATE
- CICLE : 'S' FOR SLOW - 0-15 km/h
  'M' FOR MEDIUM - 15-30 km/h
  'F' FOR FAST - 30+ km/h

I) WAS THE ROAD CLOSED BECAUSE OF THIS SNOWDRIFTING EVENT?

- CIRCLE 'Y' IF THE ROAD WAS CLOSED BECAUSE OF DRIFTING AT A SITE OTHER THAN THE STUDY SITE
- CIRCLE 'T' IF THE ROAD WAS CLOSED BECAUSE OF DRIFTING AT THE STUDY SITE
- CIRCLE 'N' IF THE ROAD WAS NOT CLOSED BECAUSE OF THIS SNOWDRIFTING EVENT

J) WAS ANY EXTRA EQUIPMENT USED TO CLEAR THE ROAD AT THIS SITE THAN IS NORMALLY USED?

- IF FOR INSTANCE, YOU NORMALLY MAINTAIN THIS SITE WITH A SANDER AND A GRADER ANSWER 'NO' IF NO OTHER EQUIPMENT WAS USED TO HANDLE THE SNOW DRIFTED BECAUSE OF THIS EVENT. HOWEVER, IF FOR EXAMPLE, A SNOW BLOWER WAS NEEDED TO CLEAR THE ROAD AT THIS SITE AFTER THIS EVENT THEN ANSWER 'YES'.

K) IS THE SNOWDRIFT AT THE SNOWFENCE EQUAL TO OR HIGHER THAN THE TOP OF THE SNOWFENCE?

- THIS OBSERVATION WILL ASSIST IN DETERMINING IF THE SNOWFENCE IS FILLED TO CAPACITY

EVENT # 11 - LINE 'D'
SITE # 1-14 - Hwy #150

EVENT # 11 - LINE 'E'
SITE # 1-14 - Hwy #150

L) ARE SNOW CONDITIONS AT THIS SITE BETTER, WORSE, OR THE SAME AS PREVIOUS WINTERS?

- THIS COMPARISON SHOULD BE MADE WITH PROBLEM CONDITIONS AT THIS SITE DURING PREVIOUS WINTERS

M) COMMENTS:

- IF SOME DESCRIPTION IS NEEDED ON ANY OF THE ABOVE SECTIONS ENTER THEM IN THE SPACE PROVIDED OR ON ONE OF THE EXTRA SHEETS PROVIDED. MAKE SURE TO IDENTIFY THE EVENT NO. AND SECTION FOR EACH COMMENT.

EXAMPLE

EVENT NO.	7	8	9	10	11	12
A) DATE	JAN.12 1987					
B) TIME OF OBSERVATION	1[30]pm					
C) LENGTH OF EVENT (hr)	15					
D) TEMPERATURE (C)	-15					
E) AMOUNT OF SNOWFALL DURING EVENT (cm)	18					
F) GROUND SNOW COVER IN NEARBY OPEN FIELD (cm)	10					
G) WIND DIRECTION	W					
H) WIND SPEED (circle one) - slow - medium - fast	S M (F)	S M F	S M F	S M F	S M F	S M F
I) WAS THE ROAD CLOSED BECAUSE OF THIS SNOWDRIFTING EVENT? (circle one)	Y (N)	Y N	Y N	Y N	Y N	Y N
J) WAS ANY EXTRA EQUIPMENT USED TO CLEAR THE ROAD AT THIS SITE THAN IS NORMALLY USED? (yes or no)	(N)	N	N	N	N	N
K) IS THE SNOWDRIFT AT THE SNOWFENCE EQUAL TO OR HIGHTER THAN THE TOP OF THE SNOWFENCE? (yes or no)	(Y) N	Y N	Y N	Y N	Y N	Y N
L) ARE SNOW CONDITIONS AT THIS SITE BETTER, WORSE OR THE SAME AS PREVIOUS WINTERS? (circle one)	(B) W S	B W S	B W S	B W S	B W S	B W S
M). COMMENTS:	NEXT PAGE					

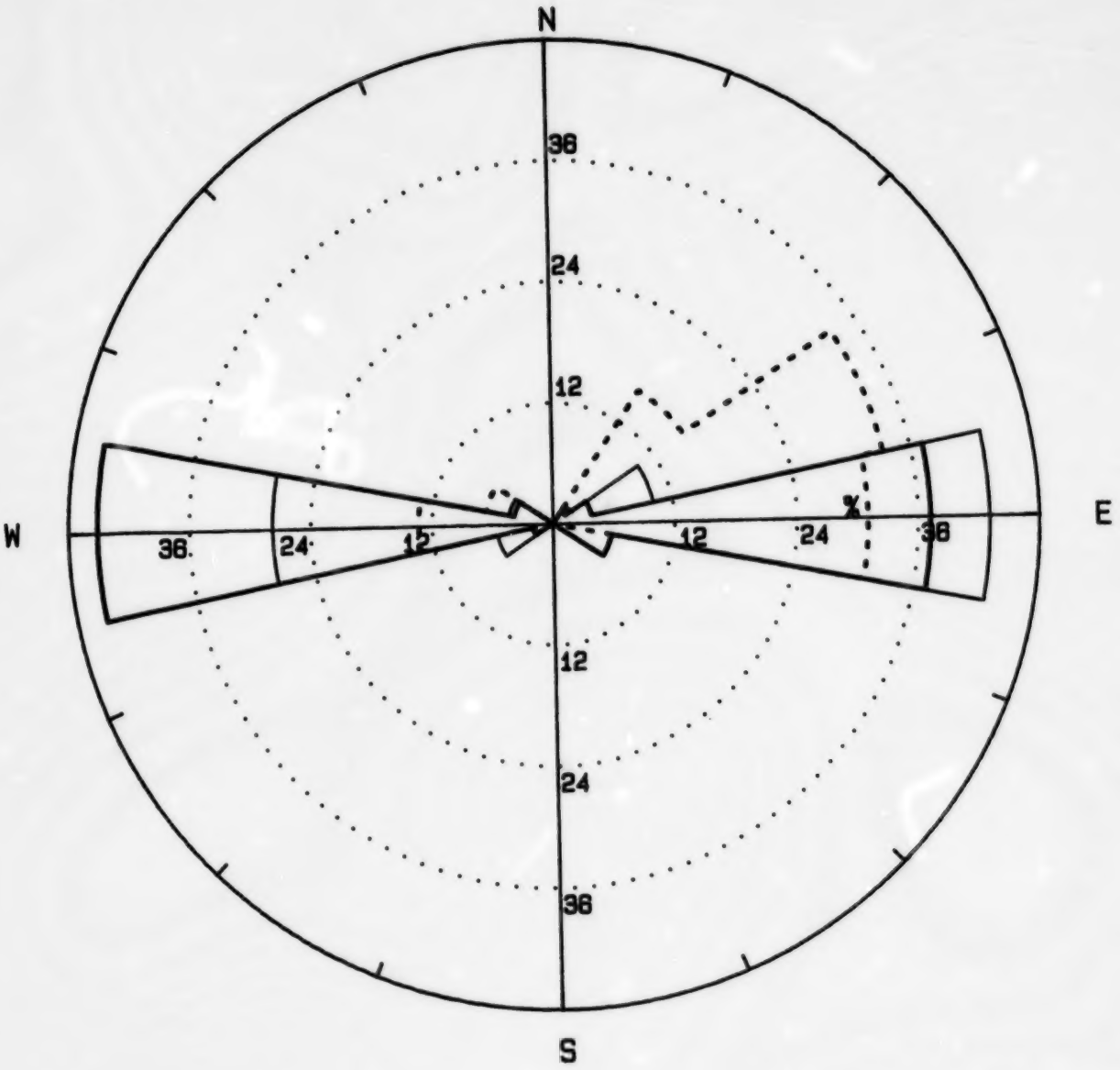
EXAMPLE

COMMENTS:

EVENT NO. 7 - SECTION K

ONE SECTION OF THE FENCE AT THE NORTH END OF THE SITE WAS FILLED WITH SNOW. THE REST OF THE FENCE HAD SNOW ABOUT HALF THE HEIGHT OF THE FENCE

APPENDIX F

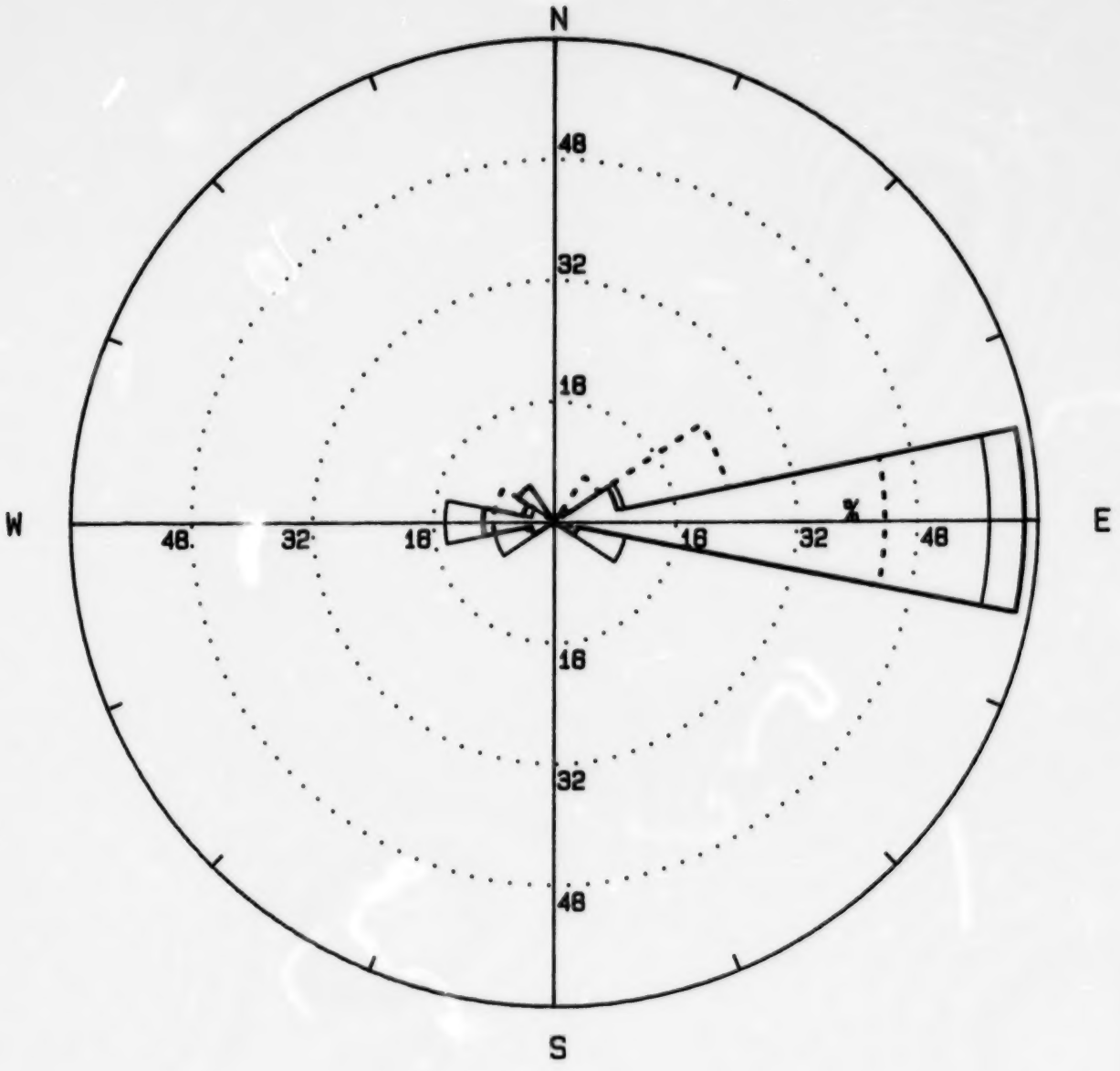


BLOWING SNOW EVENTS - CHARLO, N.B.

———— LONG TERM
- - - - - - - 86 - 87 WINTER
———— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

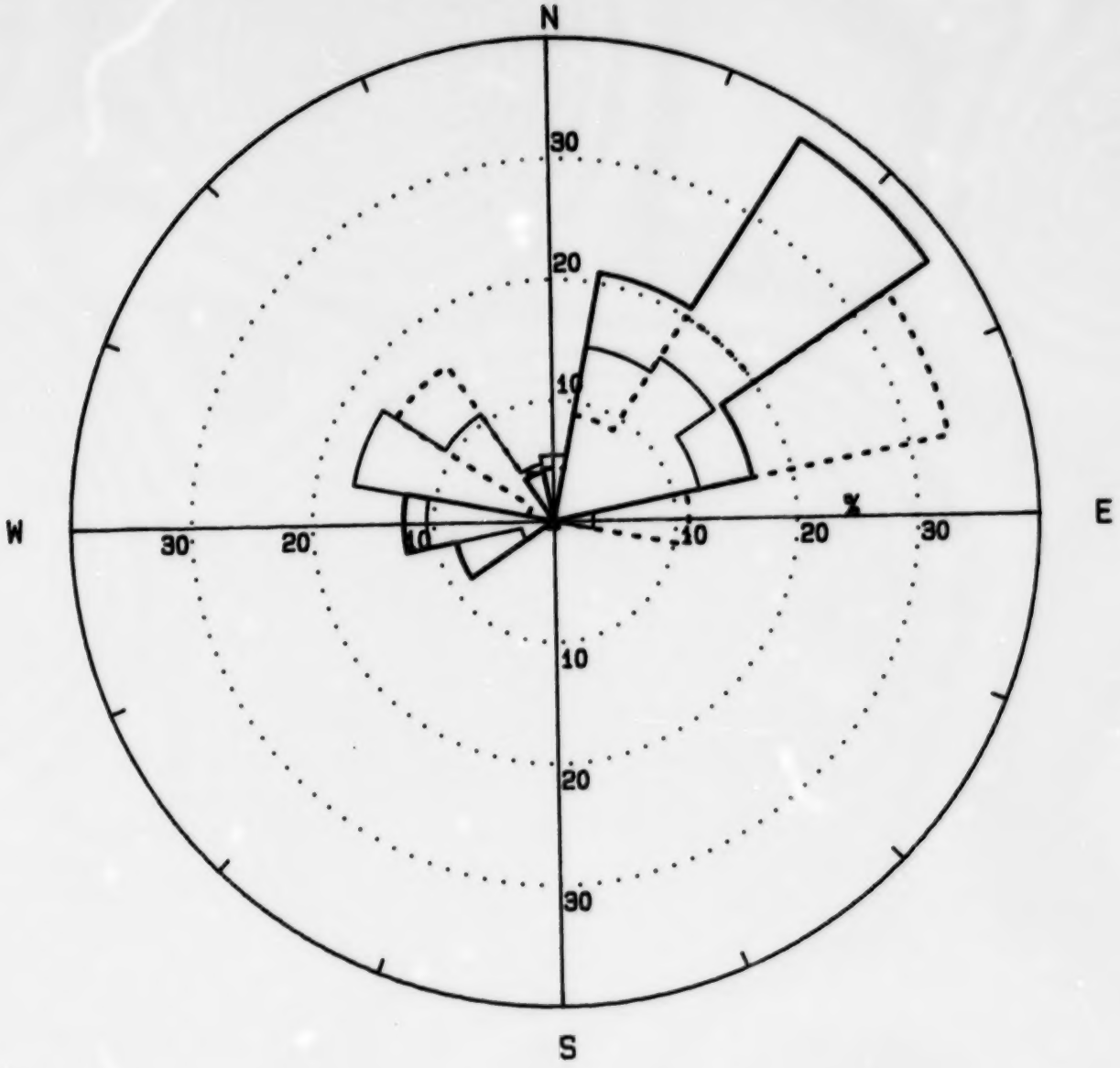


SNOWFALL WITH WIND > 15km/h - CHARLO, N.B.

——— LONG TERM
- - - - - - - 86 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

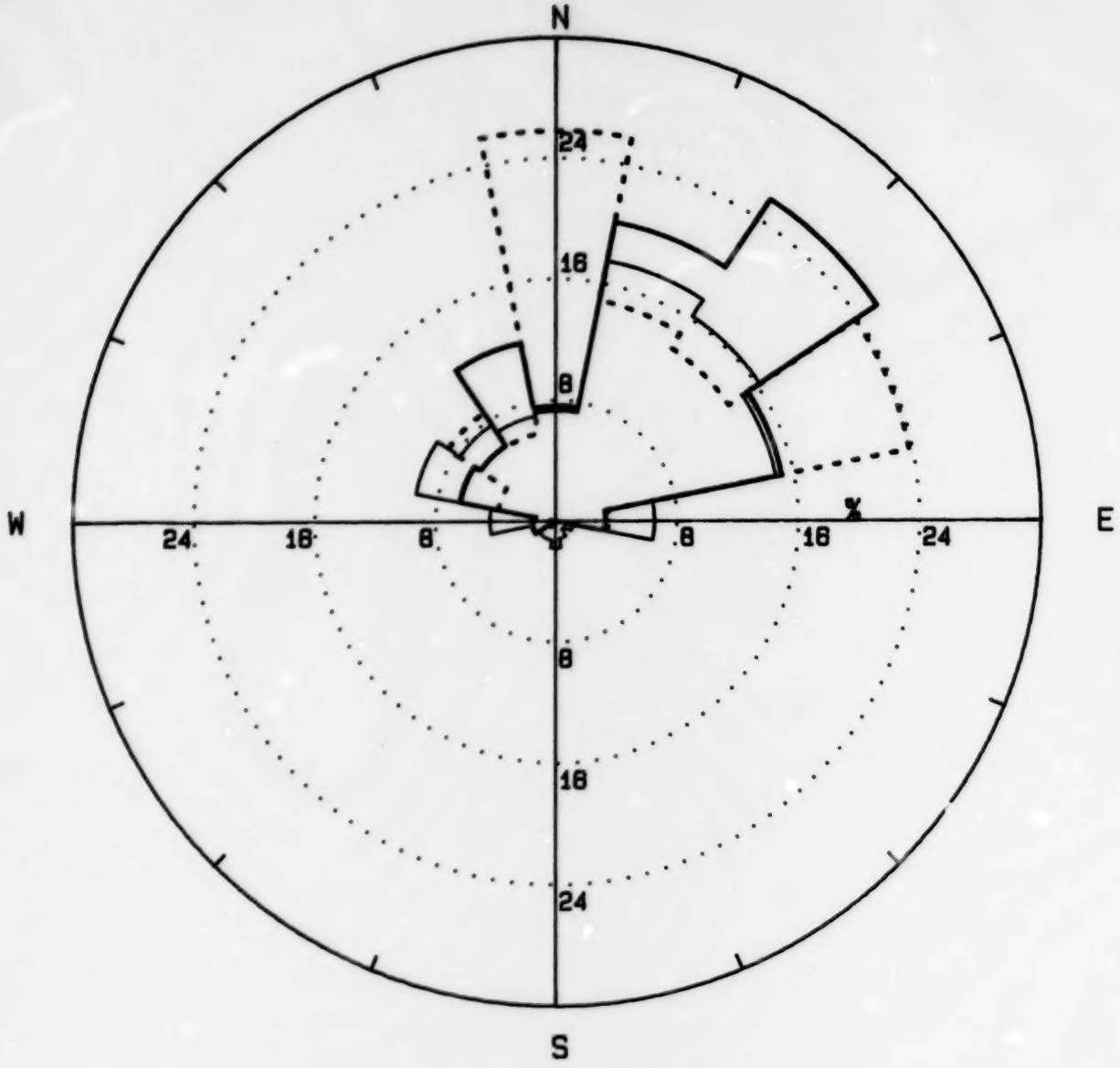


BLOWING SNOW EVENTS - FREDERICTON, N.B.

——— LONG TERM
- - - - - - - 86 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

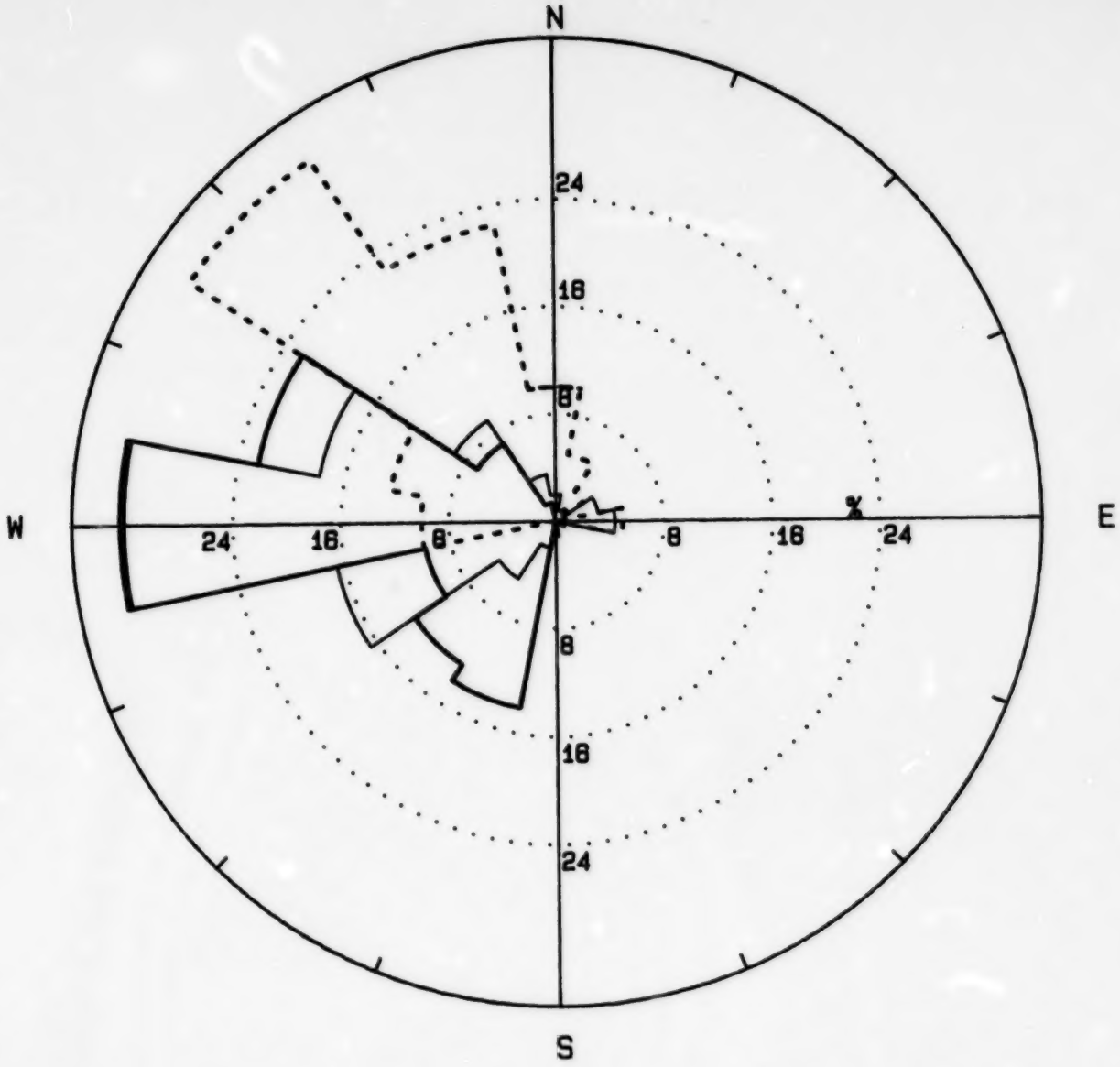


SNOWFALL WITH WIND > 15km/h - FREDERICTON, N.B.

———— LONG TERM
- - - - - - - 86 - 87 WINTER
———— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

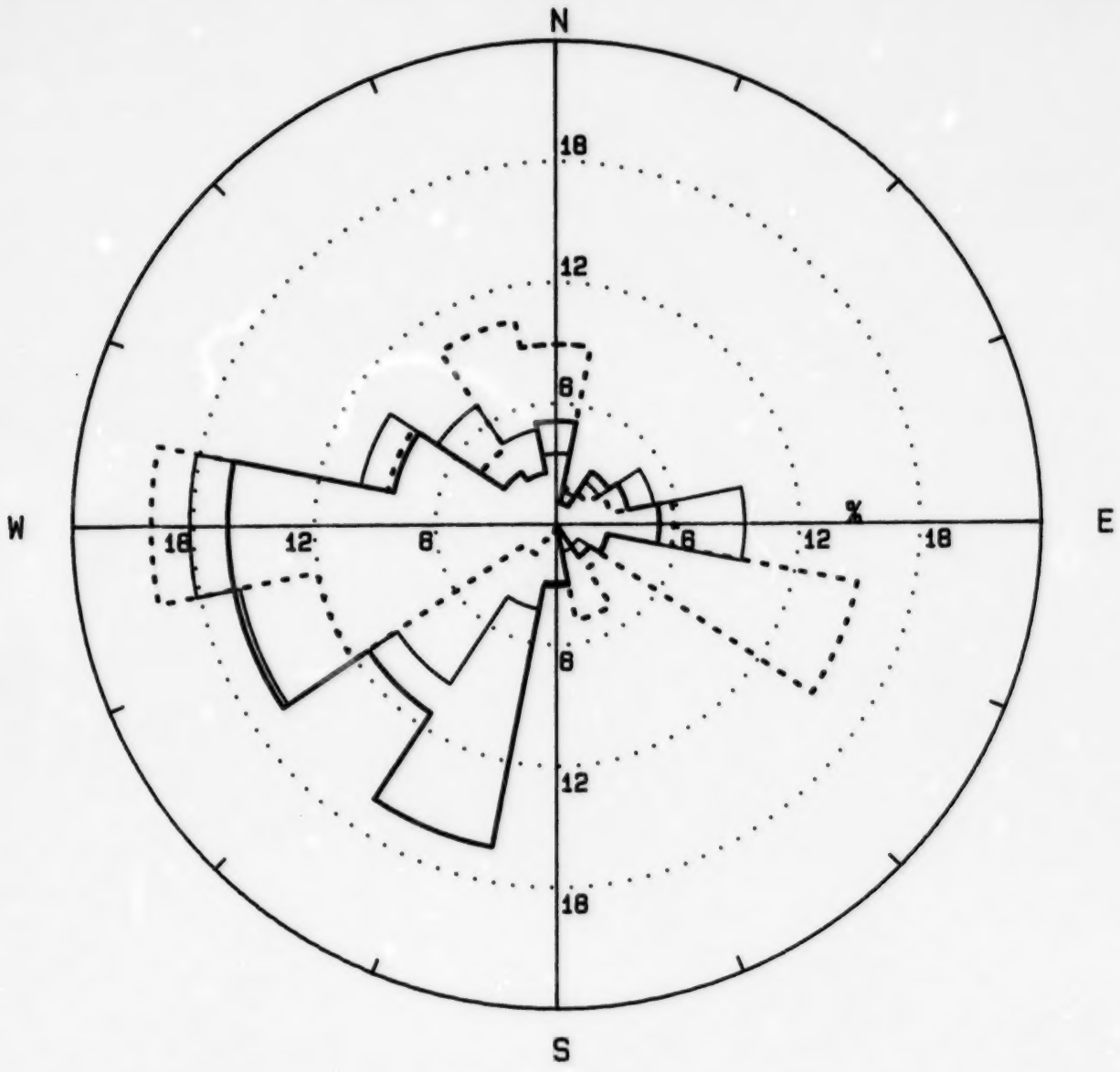


BLOWING SNOW EVENTS - LONDON, ONTARIO

——————— LONG TERM
- - - - - - - 86 - 87 WINTER
——————— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

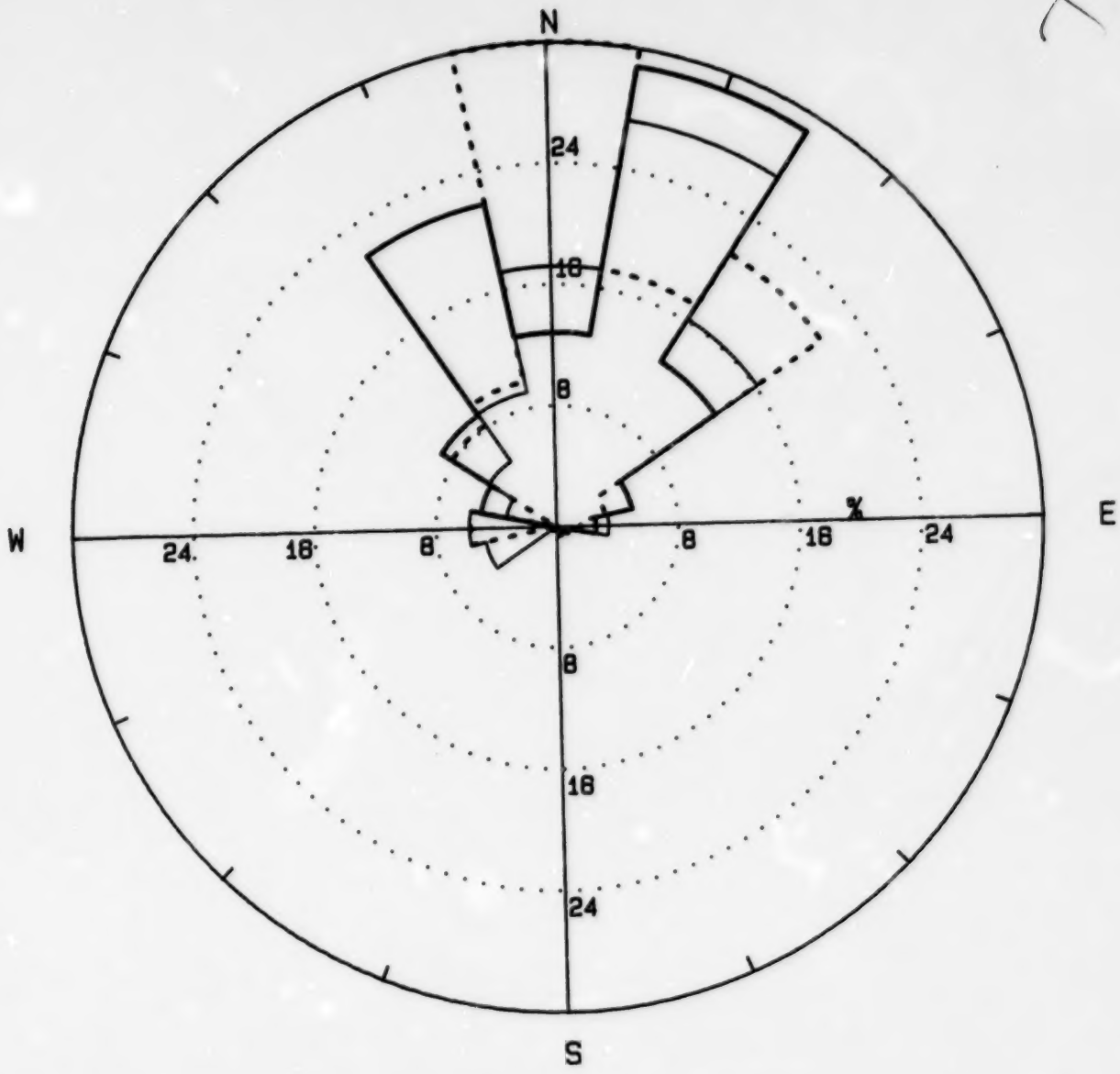


SNOWFALL WITH WIND > 15km/h - LONDON, ONTARIO

——— LONG TERM
- - - - - - - 86 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

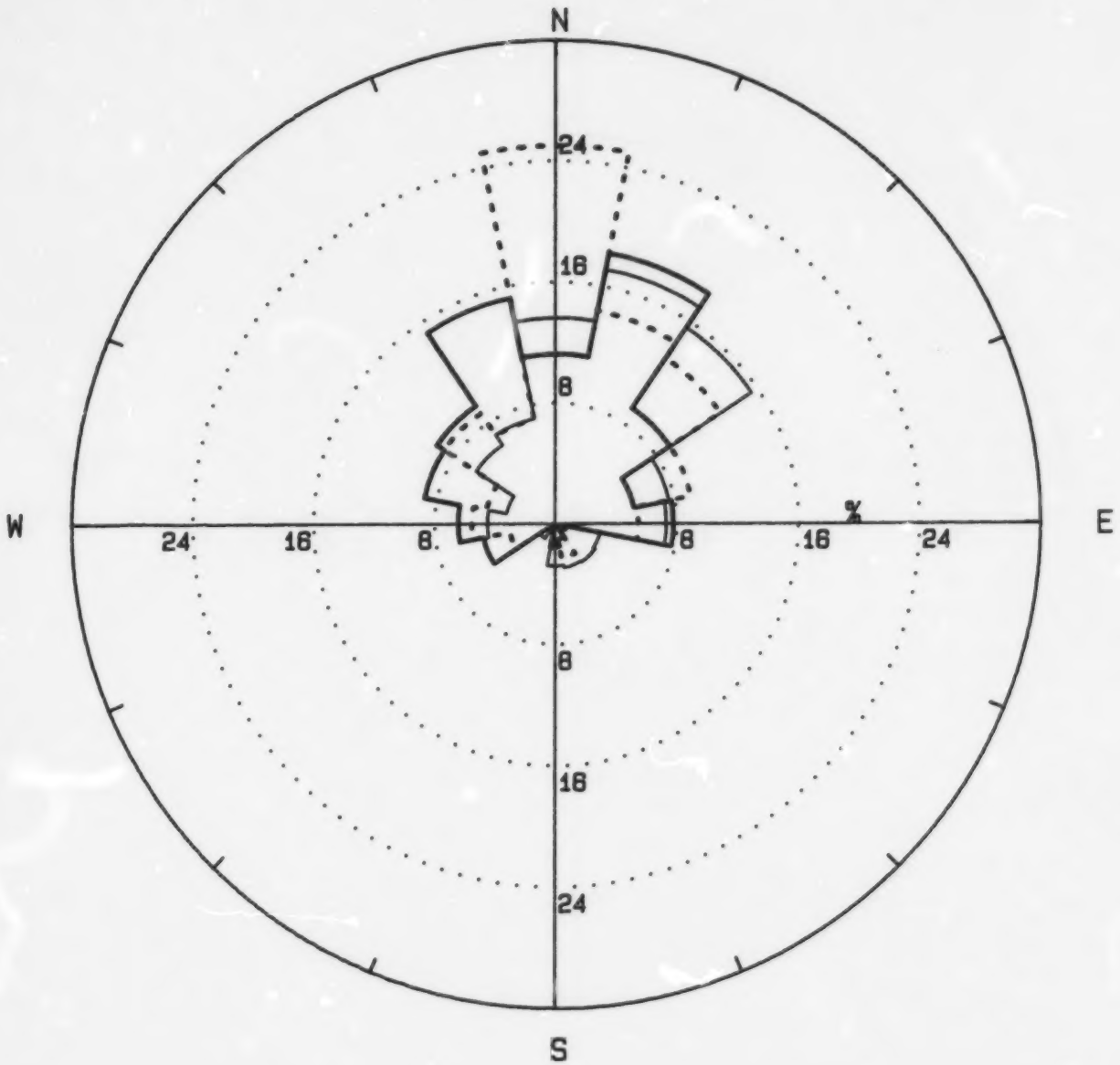


BLOWING SNOW EVENTS - MONCTON, N.B.

——— LONG TERM
- - - - - - - 86 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

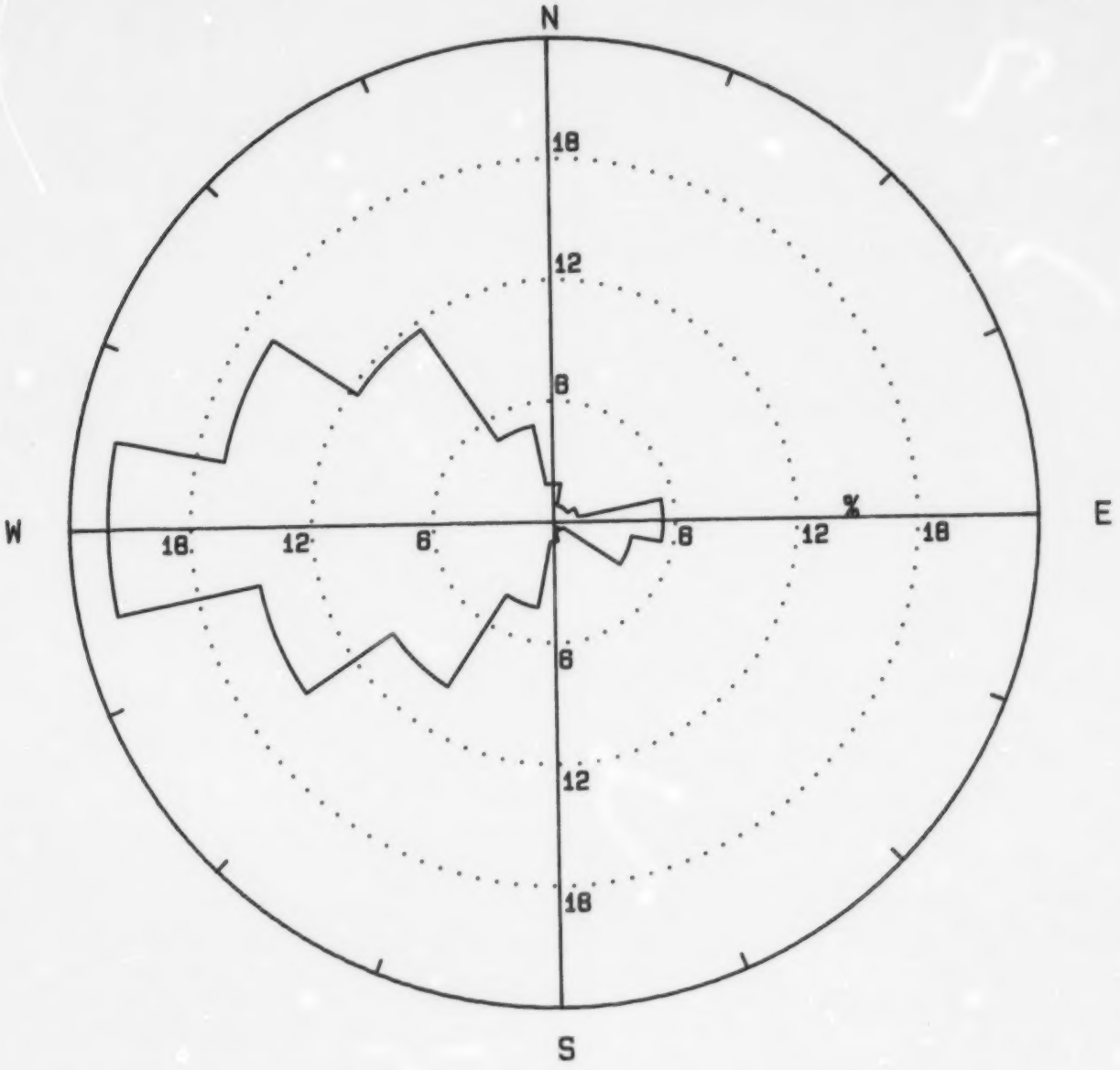


SNOWFALL WITH WIND > 15km/h - MONCTON, N.B.

——————— LONG TERM
- - - - - - - - 86 - 87 WINTER
——————— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

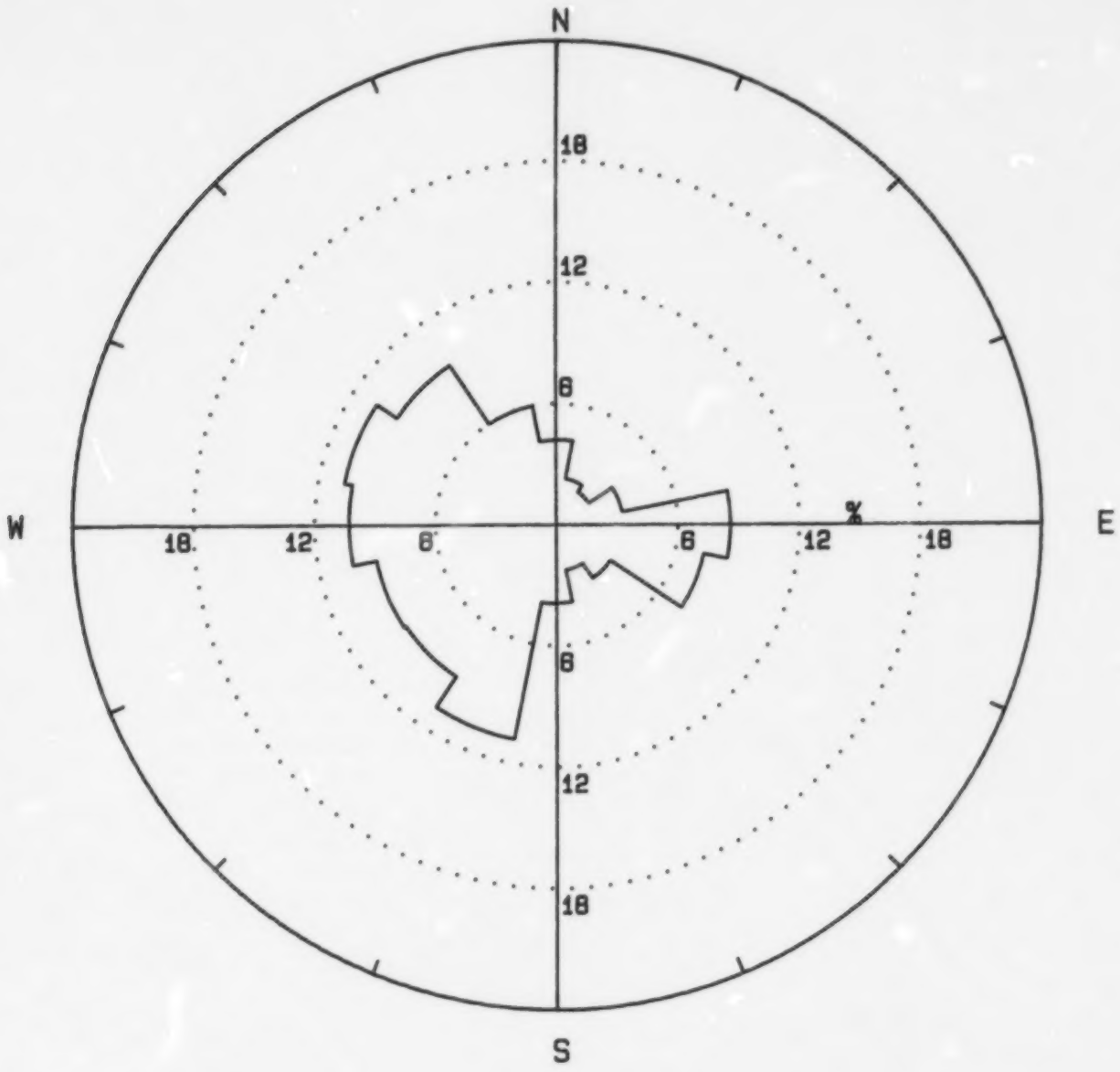


BLOWING SNOW EVENTS - MOUNT FOREST, ONTARIO

———— LONG TERM

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

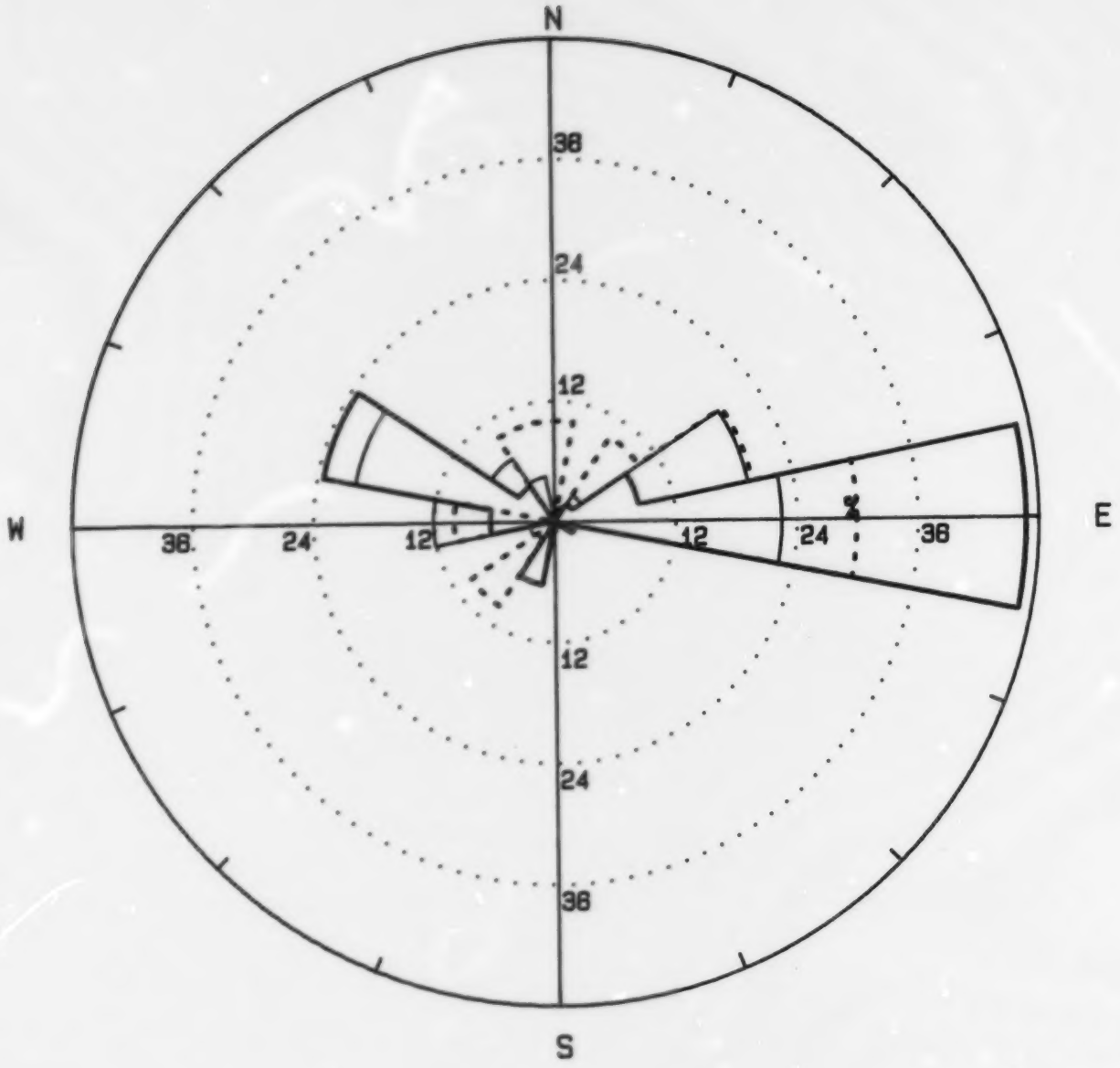


SNOWFALL WITH WIND > 15 km/h - MOUNT FOREST, ONTARIO

———— LONG TERM

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

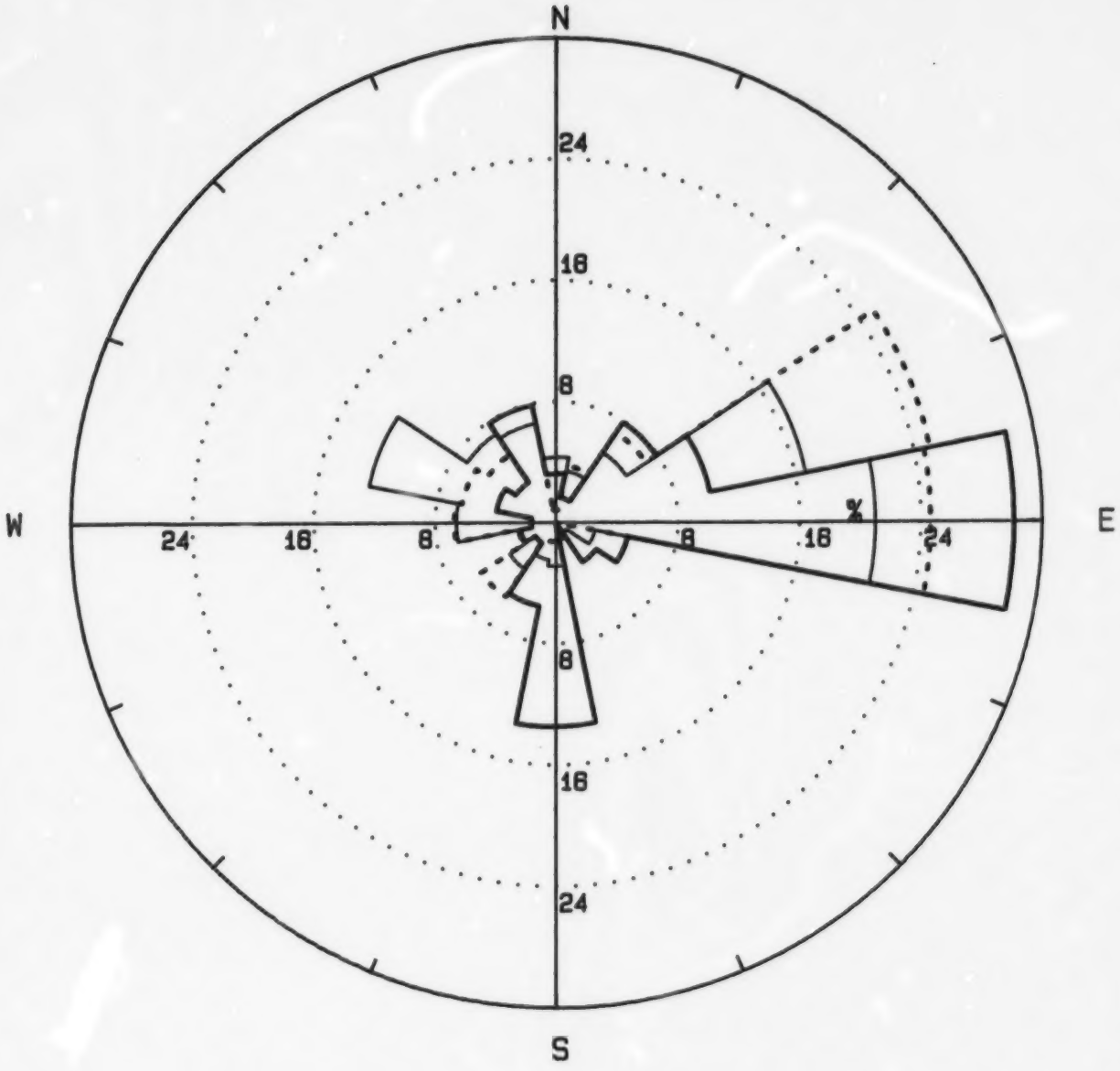


BLOWING SNOW EVENTS - OTTAWA, ONTARIO

——— LONG TERM
- - - - - - - 86 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

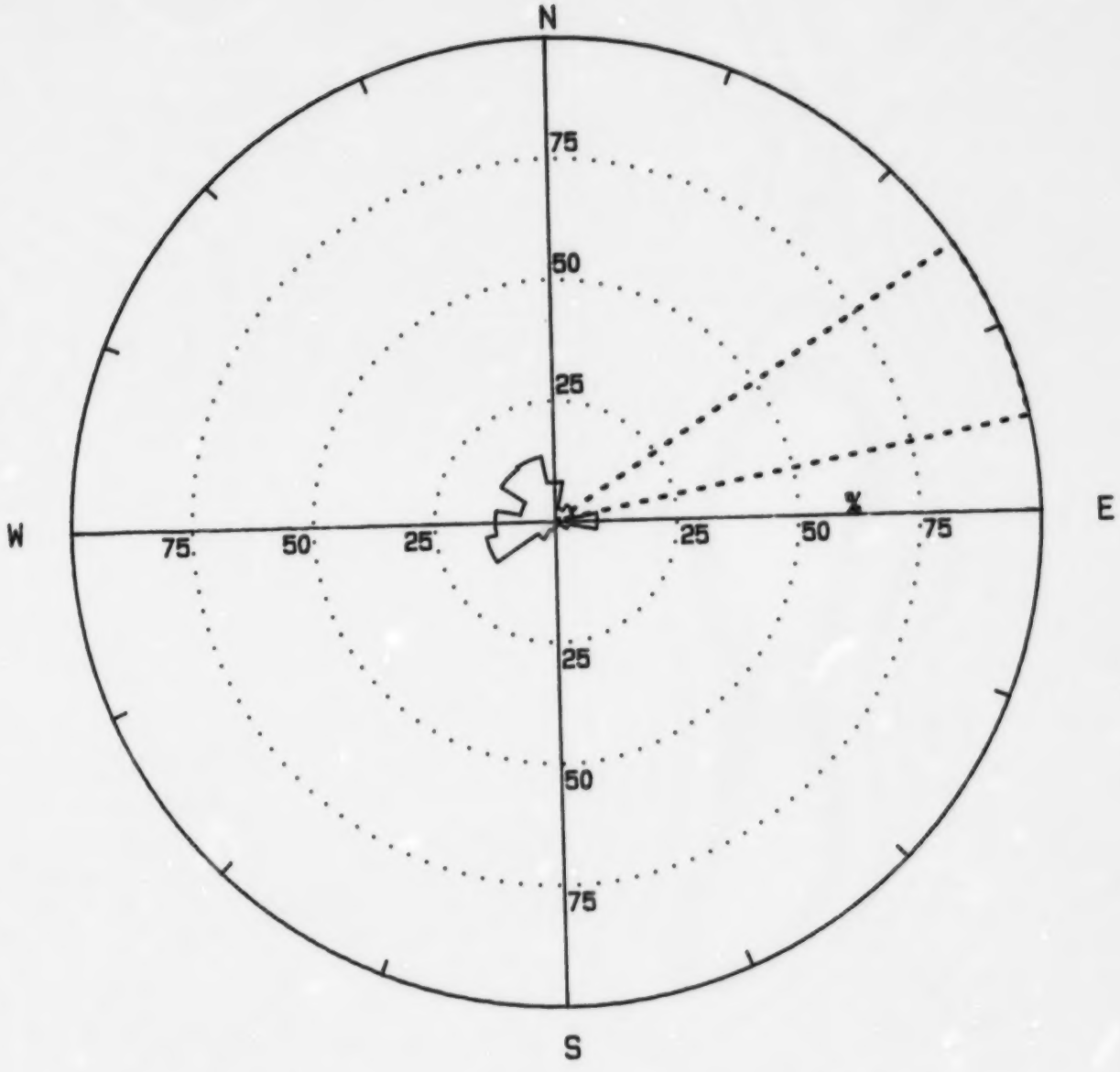


SNOWFALL WITH WIND > 15km/h - OTTAWA, ONTARIO

——— LONG TERM
- - - - - - - 86 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

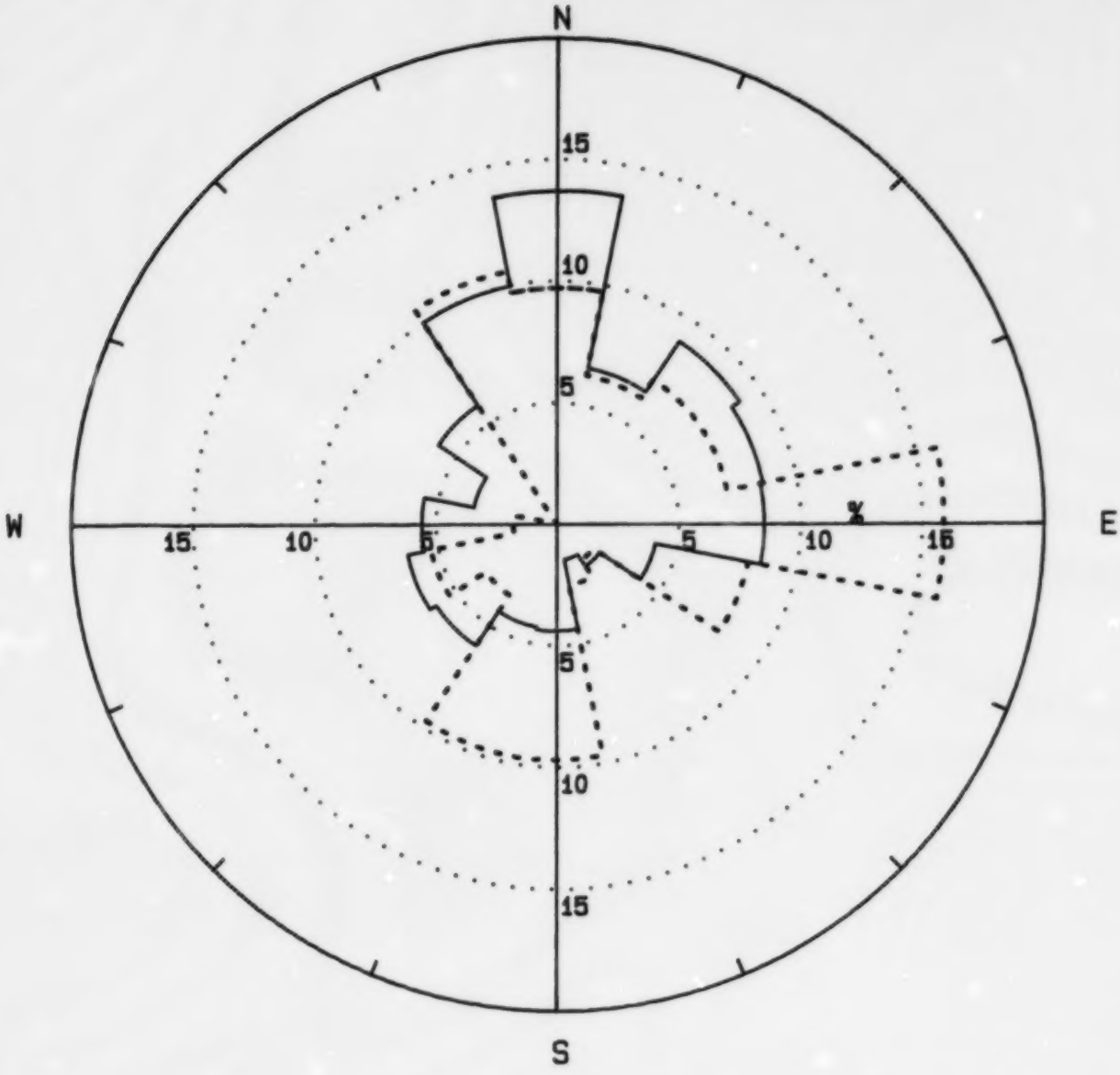


BLOWING SNOW EVENTS - PEARSON INTN'L AIRPORT

——————— LONG TERM
- - - - - - - - 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

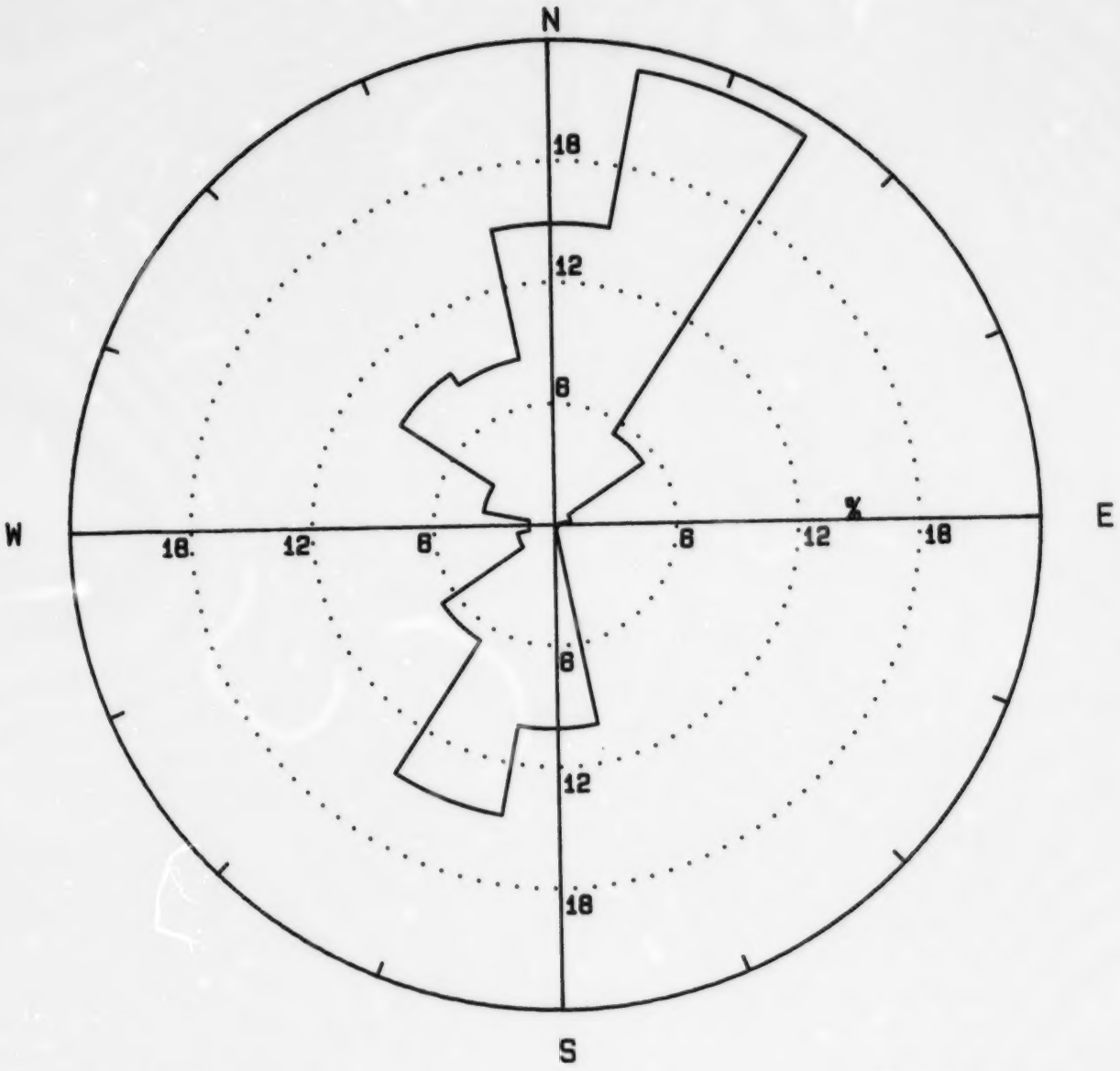


SNOWFALL WITH WIND >15 km/h - PEARSON INTN'L AIRPORT

———— LONG TERM
- - - - - - - 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

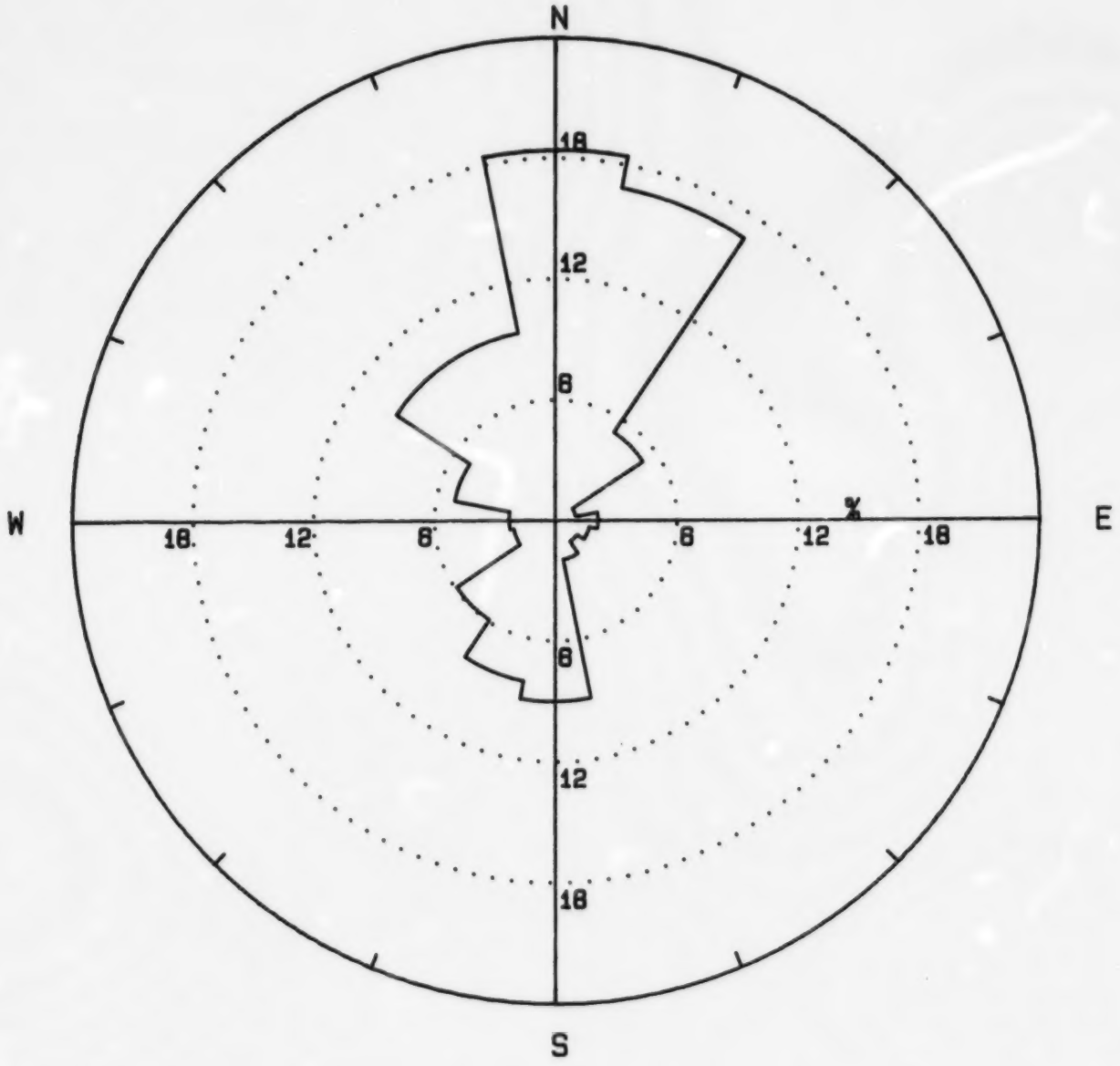


BLOWING SNOW EVENTS - RIVIERE DU LOOP

——— LONG TERM

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

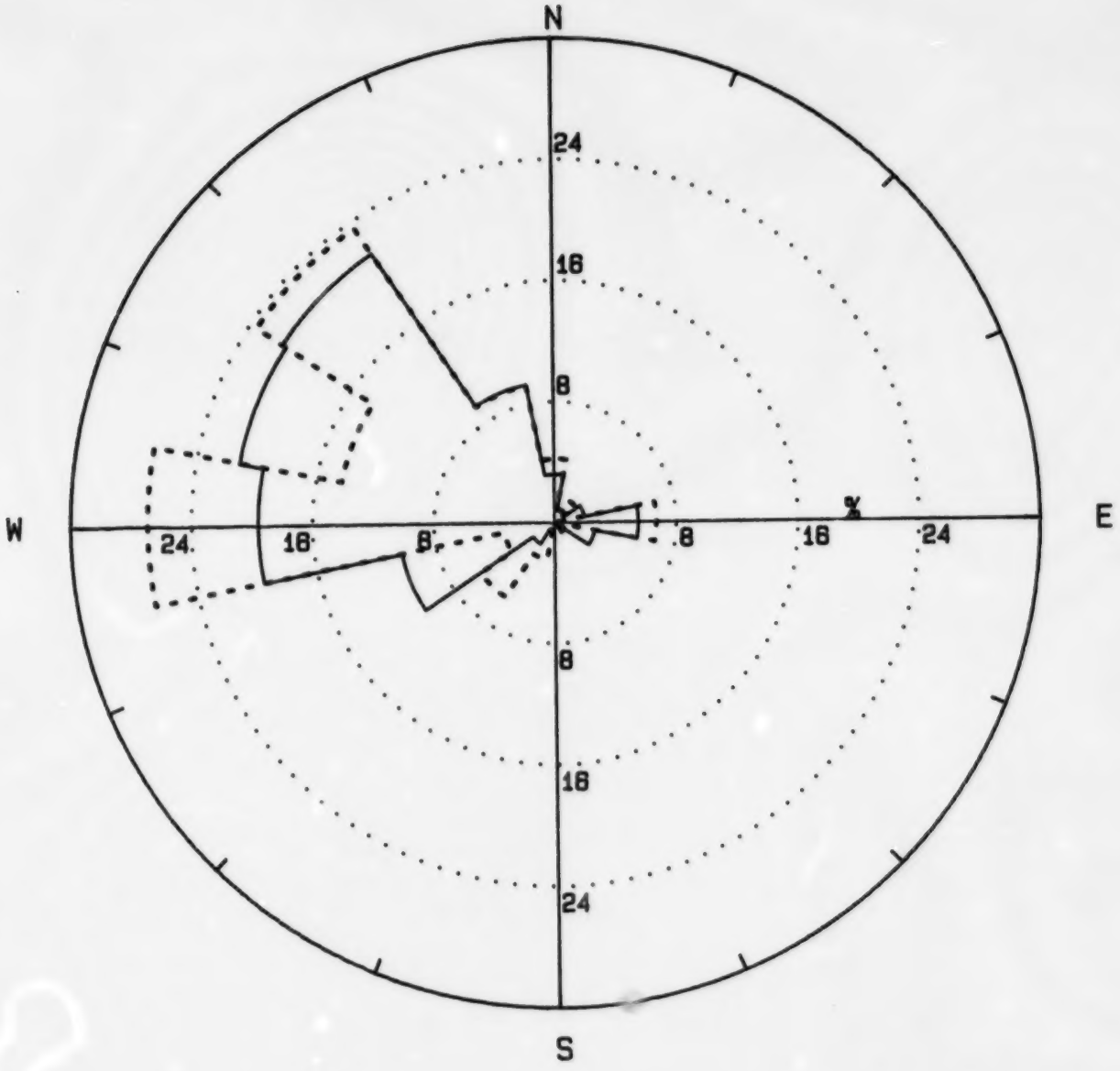


SNOWFALL WITH WIND > 15km/h - RIVIERE DU LOOP

——— LONG TERM

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

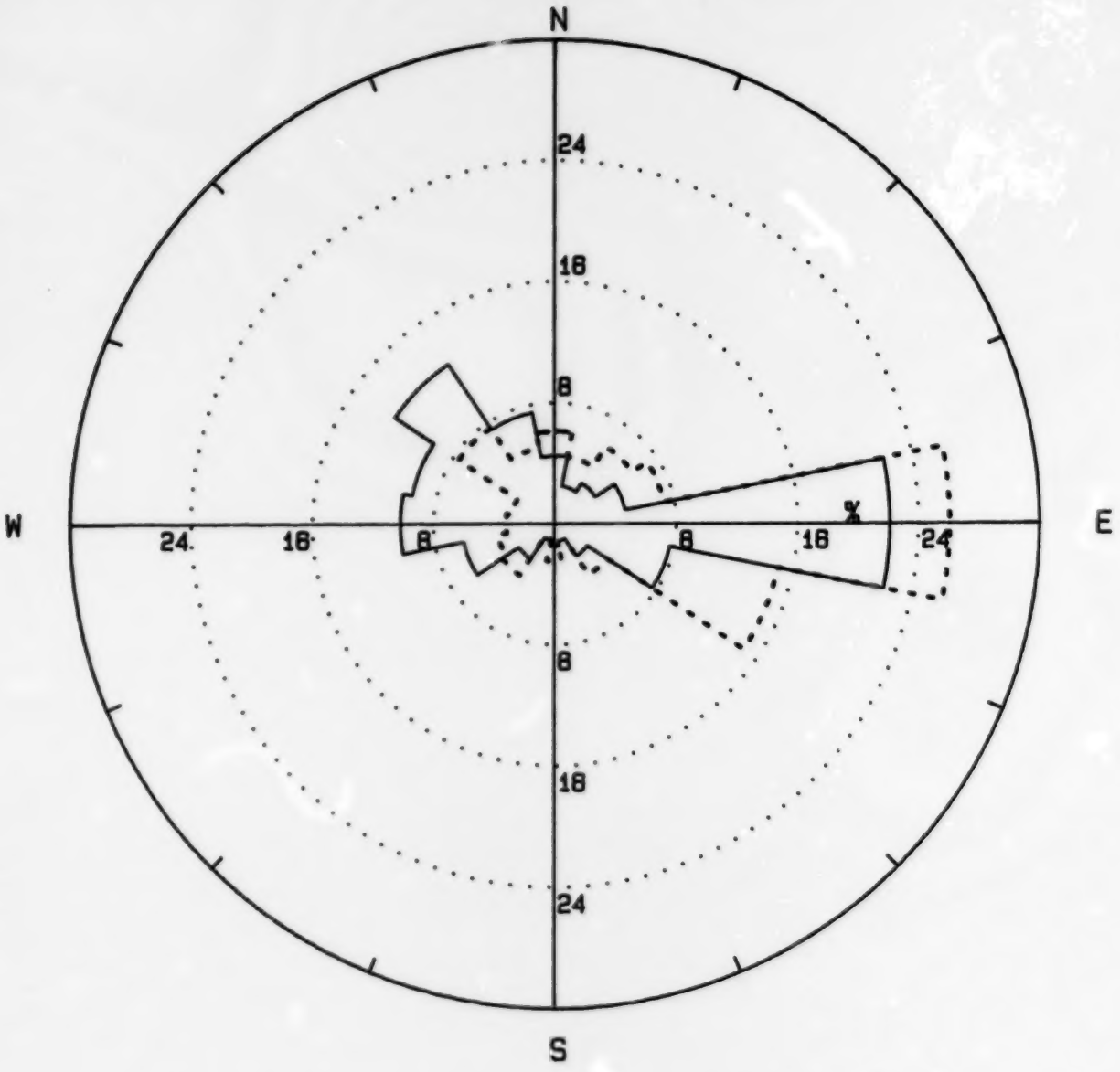


BLOWING SNOW EVENTS - SAULT STE. MARIE

——— LONG TERM
- - - - - - - 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

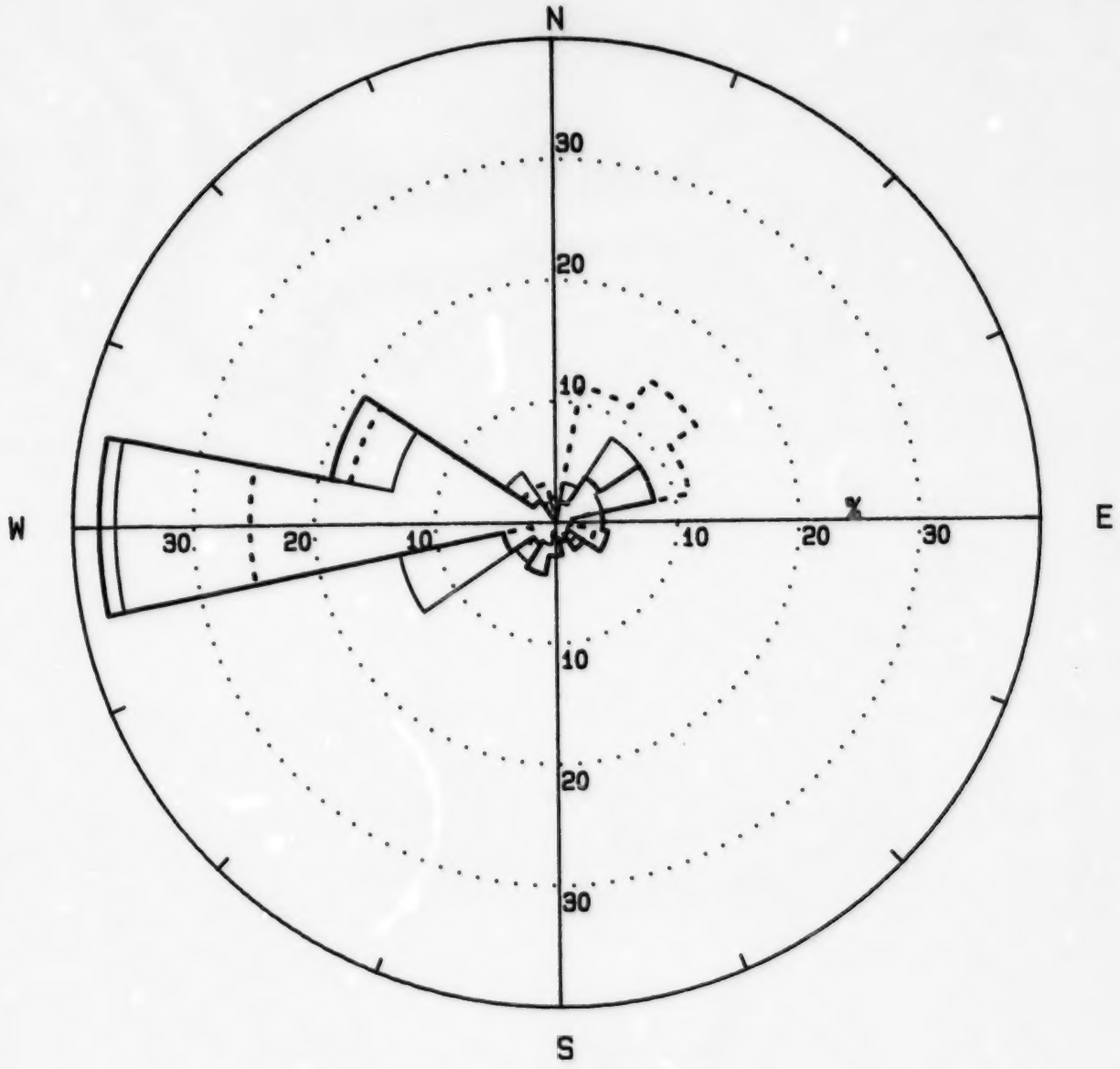


SNOWFALL WITH WIND > 15 km/h - SAULT STE. MARIE

———— LONG TERM
- - - - - - - 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

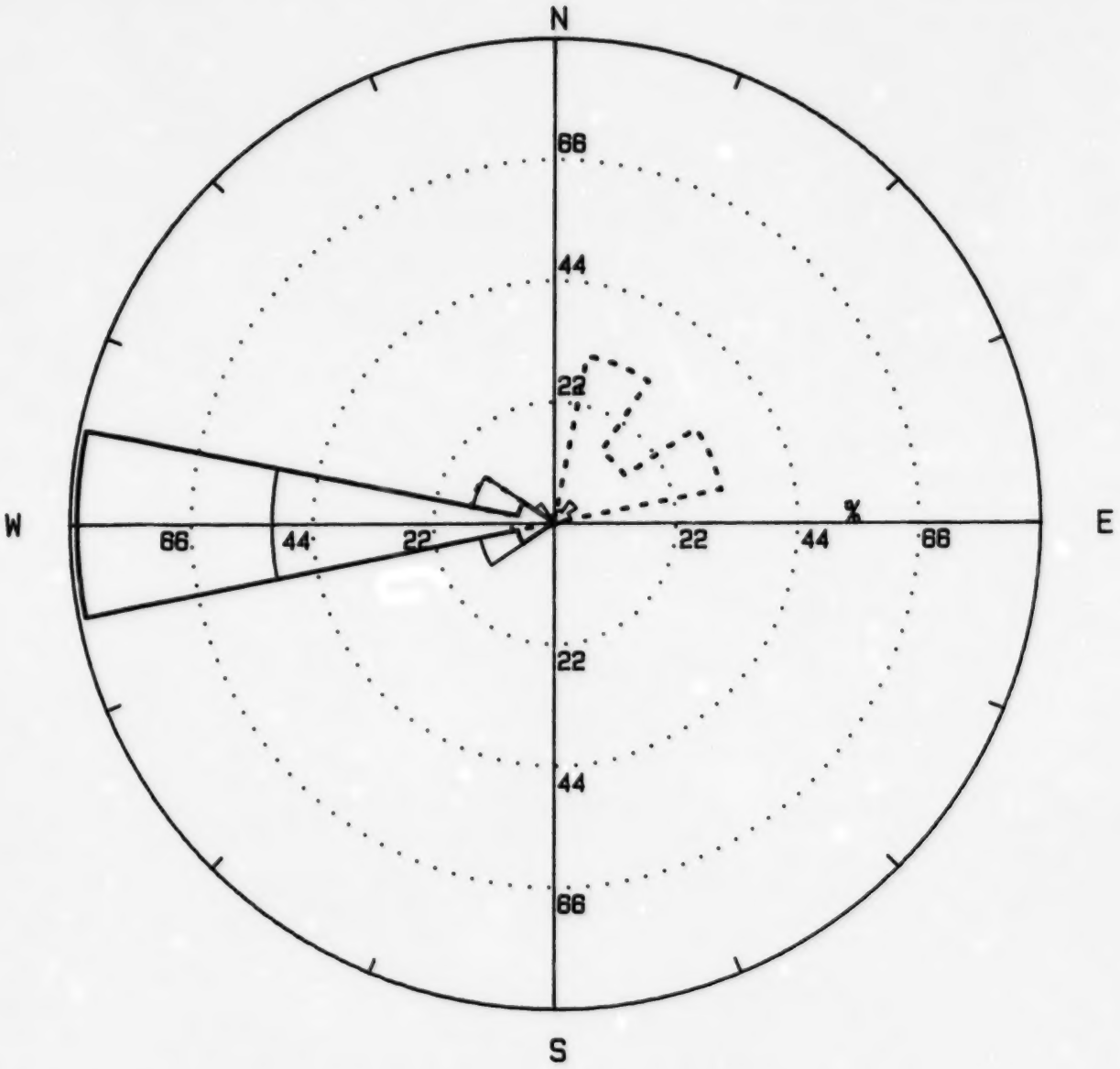


SNOWFALL WITH WIND > 15km/h - SHERBROOKE, P.Q.

——— LONG TERM
- - - - - - - 86 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

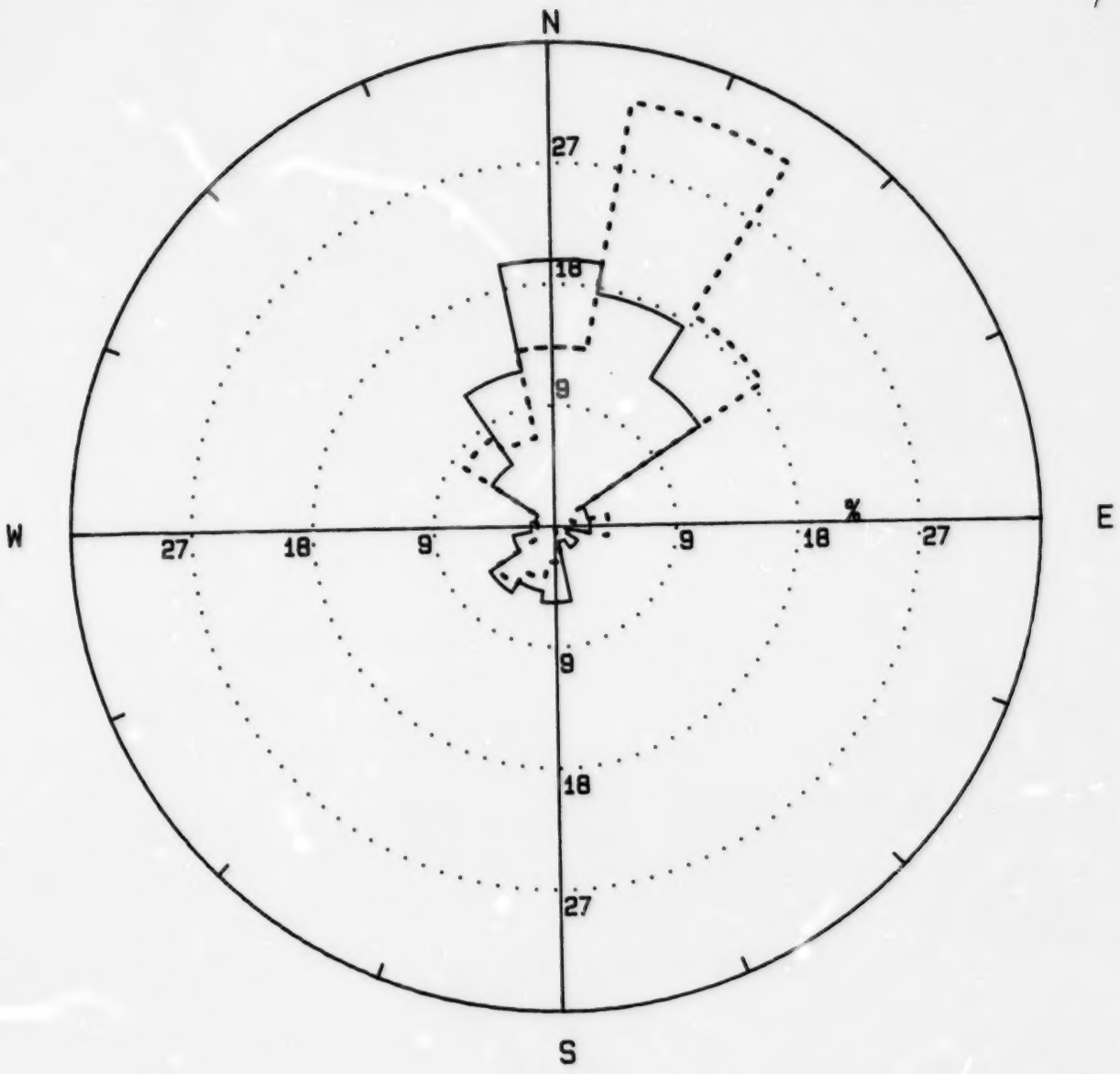


BLOWING SNOW EVENTS - SHERBROOKE, P.Q.

——— LONG TERM
- - - - - - - 86 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

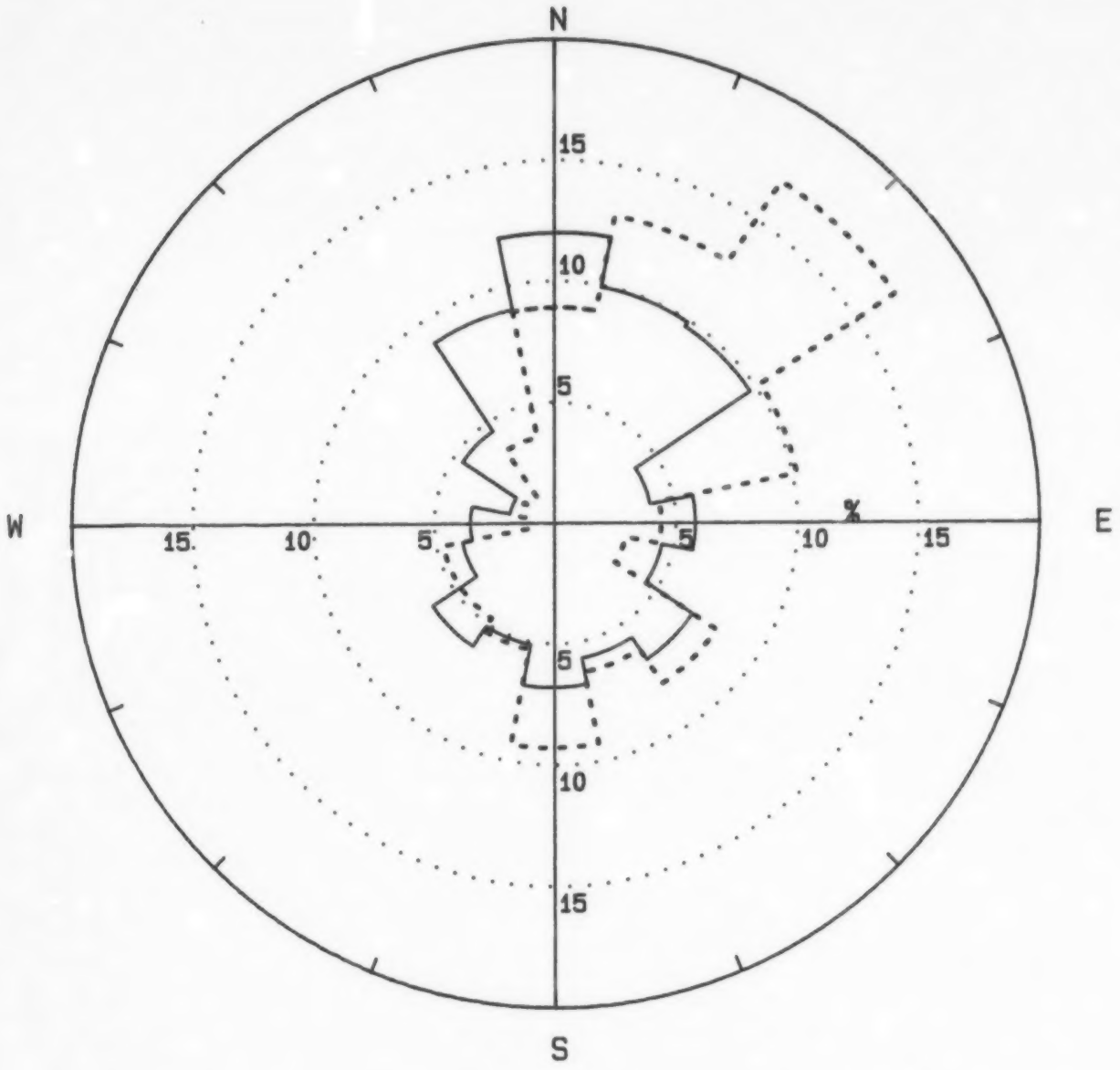


BLOWING SNOW EVENTS - SUDBURY, ONT

———— LONG TERM
- - - - - - - 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

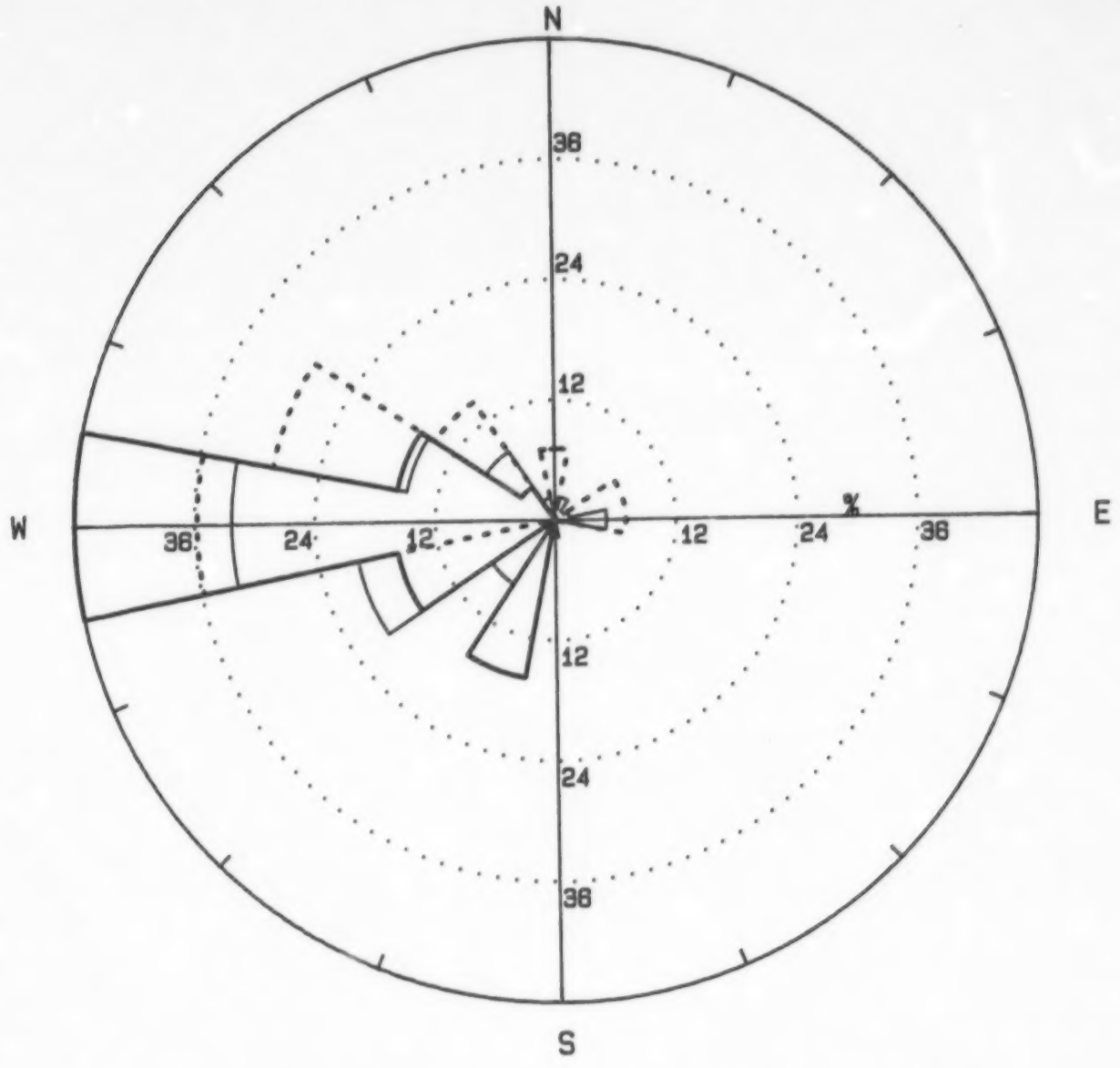


SNOWFALL WITH WIND > 15km/h - SUDBURY, ONT

———— LONG TERM
- - - - - - - 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

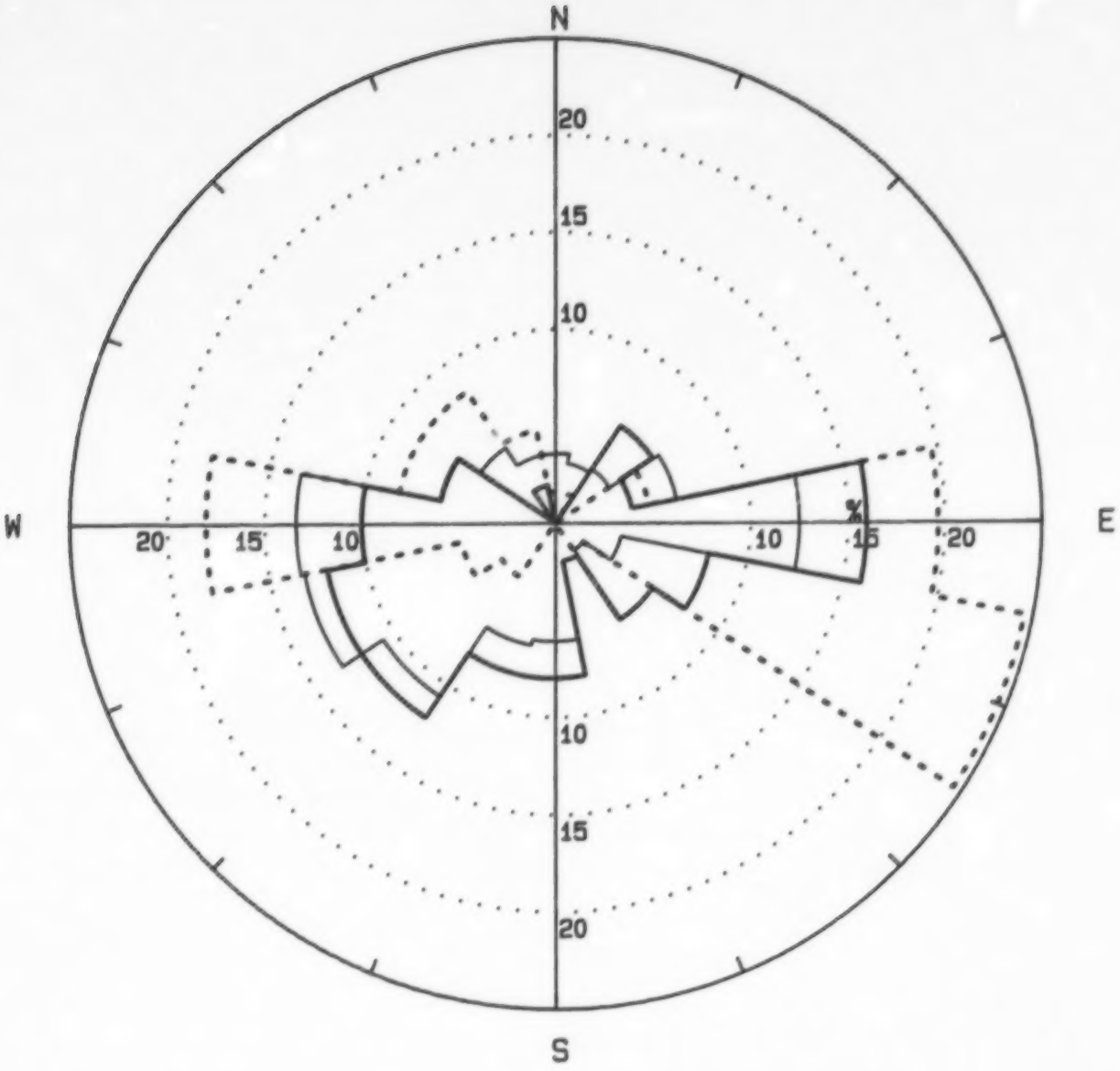


BLOWING SNOW EVENTS - WATERLOO/WELLINGTON AIRPORT

——— LONG TERM
- - - - - - - 86 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

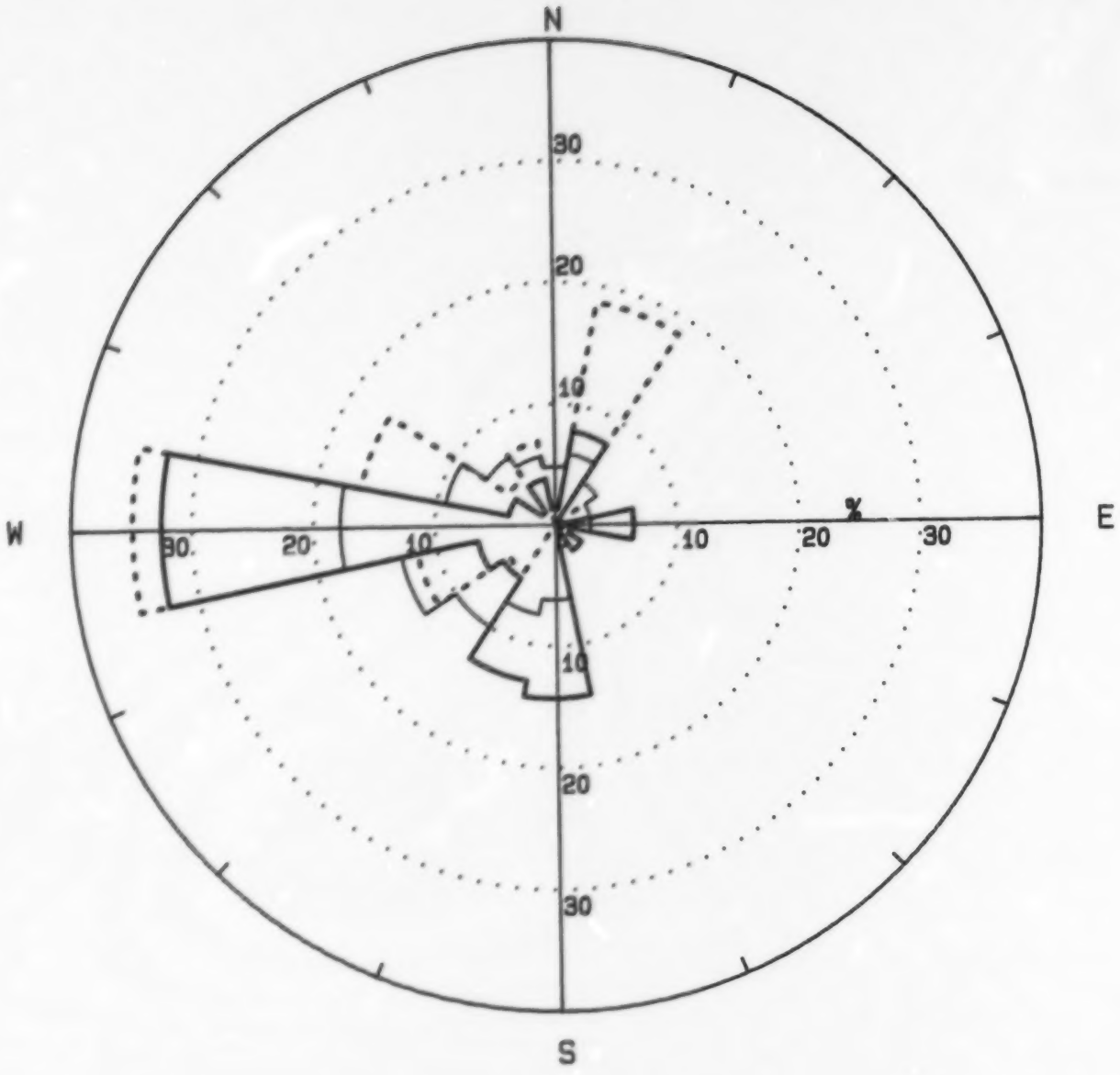


SNOWFALL WITH WIND > 15km/h - WATERLOO/WELLINGTON AIRPORT

——— LONG TERM
- - - - - - - - 86 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

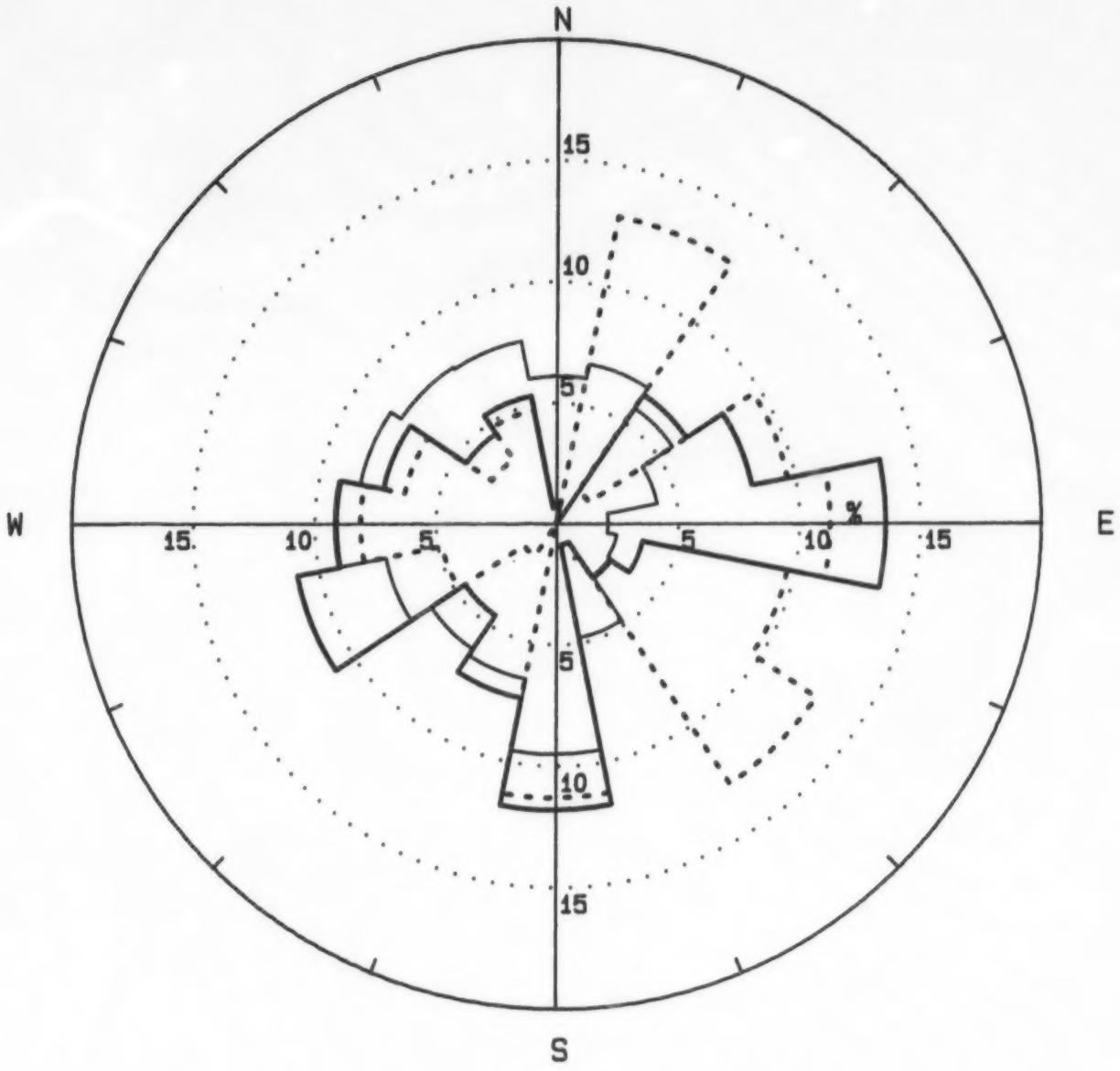


BLOWING SNOW EVENTS - WIARTON, ONTARIO

——— LONG TERM
- - - - - - - 88 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS



SNOWFALL WITH WIND > 15km/h - WIARTON, ONTARIO

——— LONG TERM
- - - - - - - 86 - 87 WINTER
——— 87 - 88 WINTER

. . . . . FREQUENCY OF OCCURRENCE IN %

TICK MARKS INDICATE FROM WHERE THE WIND IS DIRECTED
FREQUENCIES ARE FOR 22.5 DEGREE SECTORS OF THE COMPASS

TABLE F-1

SNOWFALL COMPARISON AT REPRESENTATIVE STATIONS
HIGHWAY SNOWDRIFTING STUDY
487-1219D

STATION	SNOWFALL (cm)			
	Mean Annual	1986-87 Winter	1987-88 Winter	1988-89 Winter
Charlo, New Brunswick	406.4	270.8	378.6	347.8
Fredericton, New Brunswick	290.4	313.5	284.7	252.7
London, Ontario	208.8	179.1	190.2	156.1
Moncton, New Brunswick	341.2	417.1	440.5	321.2
Mount Forest, Ontario	276.7	n/a	n/a	n/a
Ottawa, Ontario	227.3	172.2	206.2	215.2
Riviere Du Loup, P.Q.	347.0	n/a	n/a	n/a
Sault Ste. Marie. Ontario	305.7	240.7	356.5	362.7
Sherbrooke, P.Q.	322.6	n/a	n/a	n/a
Sudbury, Ontario	247.5	247.5	312.6	280.8
Toronto, Ontario	131.2	116.6	78.4	87.2
Waterloo, Ontario	154.9	172.2	127.8	129.3
Wiarton, Ontario	352.6	264.9	409.8	545.0
Inuvik, NWT	190.0	195.0	154.9	133.0
Whitehorse, Yukon	136.6	118.2	109.2	129.6

TABLE F-2

WIND OBSERVATION COMPARISON AT REPRESENTATIVE STATIONS
HIGHWAY SNOWDRIFTING STUDY
487-1219D
BLOWING SNOW*

Station	Number of Hourly Observations		
	Mean Annual	1986-87 Winter	1987-88 Winter
Charlo, New Brunswick	50	45	51
Fredericton, New Brunswick	40	45	24
London, Ontario	n/a	40	71
Moncton, New Brunswick	88	122	78
Mount Forest, Ontario	n/a	n/a	n/a
Ottawa, Ontario	57	10	47
Riviere Du Loup, P.Q.	70	n/a	n/a
Sault Ste. Marie. Ontario	127	n/a	120
Sherbrooke, P.Q.	38	13	15
Sudbury, Ontario	77	n/a	76
Toronto, Ontario	29	n/a	1
Waterloo, Ontario	36	14	25
Wiarton, Ontario	144	43	78

* as observed at local weather stations

TABLE F-3

WIND OBSERVATION COMPARISON AT REPRESENTATIVE STATIONS
HIGHWAY SNOWDRIFTING STUDY
487-1219D
SNOWFALL WITH WIND > 15 km/h

Station	Number of Hourly Observations		
	Mean Annual	1986-87 Winter	1987-88 Winter
Charlo, New Brunswick	252	112	191
Fredericton, New Brunswick	218	256	184
London, Ontario	n/a	224	196
Moncton, New Brunswick	403	328	374
Mount Forest, Ontario	n/a	n/a	n/a
Ottawa, Ontario	356	239	126
Riviere Du Loup, P.Q.	394	n/a	n/a
Sault Ste. Marie. Ontario	337	n/a	314
Sherbrooke, P.Q.	310	150	180
Sudbury, Ontario	632	n/a	528
Toronto, Ontario	210	n/a	113
Waterloo, Ontario	89	61	50
Wiarton, Ontario	451	62	110

TABLE F-4

ANNUAL PEAK GROUND SNOW COVER (cm)
HIGHWAY SNOWDRIFTING STUDY
487-1219

Station	Years of Data	4 yr Return	1986-87 Winter	1987-88 Winter	1988-89 Winter
Charlo, New Brunswick	22	115	89	105	105
Fredericton, New Brunswick	32	82	77	69	28
London, Ontario	33	44	24	21	11
Moncton, New Brunswick	34	83	92	69	42
Mount Forest, Ontario	21	54	n/a	n/a	n/a
Ottawa, Ontario	34	70	63	40	31
Riviere Du Loup, P.Q.	15	110	n/a	n/a	n/a
Sault Ste. Marie. Ontario	28	98	45	48	58
Sherbrooke, P.Q.	25	80	n/a	n/a	n/a
Sudbury, Ontario	34	83	77	78	75
Toronto, Ontario	34	33	n/a	n/a	n/a
Waterloo, Ontario	19	43	20	20	17
Wiarton, Ontario	33	80	56	68	48
St. Johns, Newfoundland	33	82	137	46	51

TABLE F-5

AVERAGE DEGREE DAYS BELOW 0.0°C/WINTER/MONTH*

1.	Victoria, British Columbia	<1
2.	Vancouver, British Columbia	<1
3.	Port Hardy, British Columbia	<1
4.	Nanaimo, British Columbia	<1
5.	Comox, British Columbia	<1
6.	Mission, British Columbia	<1
7.	Abbotsford, British Columbia	<1
8.	Chilliwack, British Columbia	<1
9.	Hope, British Columbia	1
10.	Hell's Gate, British Columbia	2
11.	Oliver, British Columbia	3
12.	Yarmouth, Nova Scotia	3
13.	Burlington, Ontario	4
14.	Kamloops. British Columbia	4
15.	Terrace, British Columbia	4
16.	Delhi, Ontario	4
17.	Hamilton, Ontario	4
18.	Halifax, Nova Scotia	4
19.	Kentville, Nova Scotia	4
20.	Shearwater, Nova Scotia	4
21.	St. John's, Newfoundland	4
22.	Corner Brook, Newfoundland	5
23.	London, Ontario	5
24.	Toronto, Ontario	5
25.	Kitchener, Ontario	6
26.	Wiarton, Ontario	6
27.	Woodstock, Ontario	6
28.	Sackville, New Brunswick	6
29.	Charlottetown, Prince Edward Island	6
30.	Summerside, Prince Edward Island	6
31.	Gander, Newfoundland	6
32.	Stephenville, Newfoundland	6
33.	Prince George, British Columbia	7
34.	Lethbridge, Alberta	7
35.	Cornwall, Ontario	7
36.	Redickville, Ontario	7
37.	Fredericton, New Brunswick	7
38.	Saint John, New Brunswick	7
39.	Halifax International Airport, Nova Scotia	7
40.	Banff, Alberta	8
41.	Calgary, Alberta	8
42.	Jasper, Alberta	8
43.	Medicine Hat, Alberta	8
44.	Guelph, Ontario	8
45.	Kemptville, Ontario	8
46.	Walkerton, Ontario	8
47.	Montreal, Quebec	8
48.	St. Hubert, Quebec	8
49.	Chatham, New Brunswick	8
50.	Fort St. James, British Columbia	9
51.	High River, Alberta	9
52.	Rocky Mountain House, Alberta	9
53.	Muskoka, Ontario	9
54.	Ottawa, Ontario	9
55.	Kananaskis, Alberta	10

* Data used as described in Reference 5

TABLE F-5 (con't)

AVERAGE DEGREE DAYS BELOW 0.0°C/WINTER/MONTH*

56.	Red Deer, Alberta	10
57.	Estevan, Saskatchewan	10
58.	Sudbury, Ontario	10
59.	Thunderbay, Ontario	10
60.	Quebec City, Quebec	10
61.	Swift Current, Saskatchewan	10
62.	Sherbrooke, Quebec	10
63.	Mont Joli, Quebec	11
64.	Shawinigan, Quebec	11
65.	Trois Rivieres, Quebec	11
66.	Moose Jaw, Saskatchewan	11
67.	Fort St. John, British Columbia	12
68.	Regina, Saskatchewan	12
69.	Kenora, Ontario	12
70.	Bagotville, Quebec	12
71.	Rimouski, Quebec	12
72.	Saskatoon, Quebec	12
73.	Brandon, Manitoba	13
74.	Winnipeg, Manitoba	13
75.	Wetaskiwin, Alberta	14
76.	Dryden, Ontario	14
77.	Whitehorse, Yukon	15
78.	Edmonton, Alberta	15
79.	Ft. McMurray, Alberta	15
80.	Prince Albert, Saskatchewan	15
81.	Hay River, NWT	17
82.	Vegreville, Alberta	17
83.	Fort Nelson, British Columbia	18
84.	Flin Flon, Manitoba	18
85.	Peace River, Alberta	19
86.	Watson Lake, Yukon	20
87.	Fort Smith, NWT	21
88.	Yellowknife, NWT	21
89.	Norman Wells, NWT	22
90.	Dawson City, Yukon	27
91.	Alert, Yukon	28
92.	Inuvik, NWT	28
93.	Baker Lake, NWT	29
94.	Sachs Harbour, NWT	29
95.	Tuktoyaktuk, NWT	29
96.	Coral Harbour, NWT	30
97.	Resolute Bay, NWT	30

* Data used as described in Reference 5

TABLE F-6

RATIO OF SNOWFALL TO 4 YR. PEAK GROUND SNOW COVER

	Mean Annual Snowfall (cm)	4 yr Peak Ground Snow Cover (cm)	Ratio
Charlo, New Brunswick	406.4	115	3.5:1
Fredericton, New Brunswick	290.4	82	3.5:1
London, Ontario	208.8	44	4.7:1
Moncton, New Brunswick	341.2	83	4.1:1
Mount Forest, Ontario	276.7	54	5.1:1
Ottawa, Ontario	227.3	70	3.2:1
Riviere Du Loup, Quebec	347.0	110	3.2:1
Sault Ste. Marie, Ontario	305.7	98	3.1:1
Sherbrooke, Quebec	322.6	80	4.0:1
Sudbury, Ontario	247.5	83	3.0:1
Toronto, Ontario	131.2	33	4.0:1
Waterloo, Ontario	154.9	43	3.6:1
Wiarton, Ontario	352.6	80	4.4:1
		Average	3.8:1